AIR FORCE

PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force SBIR Program is with the Air Force Materiel Command Deputy Chief of Staff for Science & Technology. The Air Force SBIR Program Manager is R. Jill Dickman. Do NOT submit SBIR proposals to the AF SBIR Program Manager under any circumstances. Inquiries of a general nature or problems that require the attention of the Air Force SBIR Program Manager should be directed to her at this address:

Department of The Air Force
HQ AFMC/STIP (AF SBIR Program Manager)
Wright-Patterson AFB OH 45433-5001

No additional technical information (this includes specifications, recommended approaches and the like) can or will be made available by Air Force personnel during the solicitation period. The only source for technical information is the Defense Technical Information Center (DTIC). Please refer to section 7.1 in this solicitation for further information on DTIC.

For each Phase I proposal, send one original (with red appendices A and B) and three (3) copies to the office designated below. Also, send an additional set of red appendices A and B, which are not stapled or mutilated in any way. Be advised that any overnight delivery may not reach the appropriate desk within one day.

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CATEGORY: Exploratory Development

OBJECTIVE: Develop a system to continuously define the velocity, concentration, size and distribution of weather simulate.

DESCRIPTION: A critical concern within the aerospace community is the ability of antennas and visual windows to continue transmit or receive information in all environments. As illustrated in the desert storm conflict, the defence of and delivery of ordinance is limited if weather or dust diminishes the effectiveness of the antenna windows. In order to evaluate the effectiveness of erosion and structural fracture resistance and the performance of the windows material, a system that characterize the test medium being used for the weather or battlefield dust simulation is required. The system needs to continuously determine the spatial distribution, size, velocity and direction of travel of the particles in the test flow field just prior the impact on the test specimen. The instrument should meet simulated flight environment from sea level up to 200,000 feet, speeds from 0 to hypersonic Mach numbers, and particulates size of 0.1 to 1 millimeter at concentrations from a few part per million up to opaque concentrations of typical sandstorms and typical sand grain sizes. Silica dioxide, graphite, ice and others are used to simulate impacts in wind tunnel and arc test. Weather simulates currently used consist of plastic balls, water droplets and ice crystals again of various size and concentration. Phase I should demonstrate the feasibility and phase II should result in demonstration of a prototype system in a wind tunnel at AEDC.

AF93-002TITLE: Non-Intrusive Water Droplet Size and Mass Flux Measurement AF93-002TITLE: Non-Intrusive Water Droplet Size and Mass Flux Measurement

CATEGORY: Exploratory Development

OBJECTIVE: Develop a non-intrusive water droplet size and mass flux measurement capability to support on-line engine/inlet icing testing.

DESCRIPTION: A non-intrusive system to make single point as well as spatial uniformity measurements of water droplet size of three to one hundred microns and mass flux ranges of 1.5 x E-4 to 47.0 x E-4 lbm water per lbm of air is required. The system must function in an engine test cells with ducting diameters varying from approximately three to twelve feet and in a flow field in which the water droplets will be entrained at approximately 0.2 to 0.5 Mach and provide real time or near-real time output. Current system are limited to measurement made in approximately one foot diameter duct. The system must be compatible with foreign object damage fears associated with engine tests. The accuracy of the measurement system should be plus or minus 3 microns in diameter and plus or minus ten percent of water mass flux. The system should not affect the freezing characteristic of the droplet or contaminate the water. It should be capable of scanning the entire test ducting to obtain spatial distribution of droplet size and mass flux in real time or within 10 minutes at the minimum. Phase I should demonstrate the concept and phase II will result in demonstration of a prototype system in a test cell at AEDC.

AF93-003TITLE: Infrared Viewer for Turbine Engine Internal SurfacesAF93-003TITLE: Infrared Viewer for Turbine Engine Internal Surfaces

CATEGORY: Advanced Development

OBJECTIVE: Develop an infrared viewer for mapping the radiation emitted by the internal surfaces of turbine engines.

DESCRIPTION: The interpretation of infrared imagery data for inclusion in aircraft propulsion signature prediction computer codes requires the measurement, at near normal viewing angles, of the radiation emitted from the internal surfaces of the engine exhaust nozzles undergoing test at simulated altitudes. The Infrared Viewer should be capable of mapping the radiation emitted from the entire internal surface of the tailpipe with a spatial resolution of +- 2.0 cm. The viewing angle should be near normal to the surface (plus or minus 20 degrees). The viewer should be capable of making measurements in the 2.5 to 14.0 micron band. The viewer should have a signal to noise ratio of at least 10 and an absolute accuracy of +- 10% while measuring radiation in the 2.5 to 14.0 micron band from a 70.0 degree C black body surface. The viewer should be capable of operating in a tailpipe with an inside diameter from 30 to 100 cm with a total length of up to 180 cm. The diameter of the viewer at the engine nozzle exhaust plane shall be no greater than 5.0 cm. The viewer should be capable of operating in an exhaust gas stream with a total pressure of 3.0 atmospheres and a total temperature of 975. degrees C. The viewer should be capable of scanning and recording the data for the entire engine tailpipe in 60 seconds or less. During Phase I the initial concept will be formulated, initial feasibility calculations performed, and optical breadboard of the system set up and an adequate signal to noise ratio demonstrated. During Phase II a detailed design for a prototype viewer will be prepared and a prototype suitable for installation in a turbojet engine altitude test cell will be built, checked out at the contractors facility, and delivered to AEDC.

AF93-004TITLE: Storage Heater Material OptimizationAF93-004TITLE: Storage Heater Material Optimization

CATEGORY: Exploratory Development

OBJECTIVE: Determine the composition of yttria stabilized zirconia which minimizes life cycle cost.

DESCRIPTION: Regenerative storage heaters possess the potential to provide high temperature, high mass flow, particle-free, and chemically correct air to hypersonic wind tunnels. Temperatures on the order of 4600 degrees Rankine are believed achievable using known materials and heat transfer design methods. One parameter which significantly impacts heater life-cycle costs is the percent yttria required to stabilize zirconia. Other known parameters are: thermal stress effects, material erosion, and the standby temperature (minimum allowable temperature of the material between runs) of the heater. Engineering development of an optimum material which minimizes total life cycle cost (factoring in capital costs, material maintenance costs, standby temperature maintenance costs, and operational costs) is critical to the feasablitity of the concept. In Phase I, an analysis will be performed to arrive at a proposed optimally designed material for use in a facility similar to the "Tripletee" facility described in the reference, except the bed dimensions will be 7 feet in diameter and 21 feet in length. Factors in facility design which will effect the optimum material design will be identified. In Phase II, samples of the proposed optimum material will be constructed and tested in order to validate the analysis performed in Phase I.

AF93-005TITLE: High-Speed Flow VisualizationAF93-005TITLE: High-Speed Flow Visualization

CATEGORY: Exploratory Development

OBJECTIVE: Visualization system for flow structure about aerodynamic shapes in transient, hypersonic flow.

DESCRIPTION: A flow visualization system is required to provide imaging of real gas flow structure (shock standoff distance, shock position, boundary layer) about aerodynamic shapes in transient, hypersonic ground test facilities at Arnold Engineering Development Center. Present visualization systems can obtain only one image during a tunnel run, and this is inadequate for defining the temporal characteristics of the flow over an aerodynamic shape. Typical freestream conditions for an air flow are 1400 K static temperature and 4E+17 molecules per cubic centimeter static density for a Mach number of approximately 7.4. An imaging rate of at least 80 KHz is required in order to obtain at least 80 images during the nominal 1 millisecond run time. In order to provide discrimination against flow and model radiation, the system will have to contain a high speed, short duration illumination system. Nine inch diameter Suprasil ports are available for viewing and illuminating the flow, and the entire system can be mounted to and isolated from the

shock tunnel. Phase I should focus on conceptual development, parametric studies, and feasibility calculations. Phase II should result in a prototype system to be tested in a transient, hypervelocity facility at AEDC.

AF93-006TITLE: Hypervelocity Projectile Balloting ModelAF93-006TITLE: Hypervelocity Projectile Balloting Model

CATEGORY: Advanced Development

OBJECTIVE: Develop a mathematical model to predict balloting of models in hypervelocity ranges such as the AEDC G-Range.

DESCRIPTION: A prediction code to accurately determine the balloting (lateral bouncing) of models in hypervelocity ranges needs to be developed. The code should be able to integrate the effects of imperfect launch tube straightness, dynamic gas forces, projectile wear, and interactions of all causes. There has been research into this field by the U.S. Army, however the effects of gas dynamics on balloting were not considered. The Phase I effort should include an evaluation of the state of the art in code development, determination of the theoretical basis for the code, and conceptual design of an appropriate computational model to address hypervelocity range projectile balloting. Phase II should be development of the actual computational tools, to include hardware and software, resulting in a system which is able to predict balloting in hypervelocity ranges. A validation comparison of computational predictions versus actual data from AEDC G-Range tests should be accomplished at the completion of the Phase II effort.

AF93-007TITLE: Defense Non-aqueous Phase Aquifer RemediationAF93-007TITLE: Defense Non-aqueous Phase Aquifer Remediation

CATEGORY: Basic Research

OBJECTIVE: Develop a chemical/physical treatment process to remediate aquifers contaminated with dense nonaqueous phase liquids (DNAPLSS) in situ

DESCRIPTION: Hazardous waste sites contaminated with DNAPLS (usually chlorinated solvents) present special problems to remediation activities. The dense organics sink to the bottom of the aquifer to form pools or disassociated droplets (ganglia) of pure phase product. This pure phase then slowly leaches into the surrounding aquifer, providing a long term source of contamination.

Phase I: Is the development and proof of concept of a treatment system to remediate a 10 cubic foot test cell contaminated with trichloroethylene. It will also provide scale up and operating parameters for a phase ii effort. Restoration verification of the test cell will include soil analysis down to the parts per million level and water analysis down to the parts per billion level.

Phase II: If approved, will be the operation of the treatment system at a contaminated air force selected site. Bioremediation and "pump-and treat" technologies are outside the scope of this topic.

AF93-008TITLE: Biological Methods for Complete Destruction of Nitro-substituted ContaminantsAF93-008TITLE: Biological Methods for Complete Destruction of Nitro-substituted Contaminants

CATEGORY: Basic Research

OBJECTIVE: Develop innovative biological methods for the destruction or biodegradation of nitro-substituted compounds in contaminated soil or waste streams.

DESCRIPTION: Knowledge surrounding the biodegradation of nitrogenous contaminants such as energetics, missile

fuels, and nitroaromatic solvents and explosives is limited. Early research led to the conclusion that nitro compounds either resist biodegradation or are reduced to amines which are more toxic than the parent compounds. Recent research conducted at the air force civil engineering laboratory has suggested that novel oxidation reactions can completely detoxify nitrogenous contaminants. These discoveries suggest that biological treatment will be effective for degrading nitrogenous compounds. Current technologies include composting and incineration. The composting process produces unknown, potentially toxic, intermediates and incineration is an extremely expensive treatment option. There is an ongoing need to understand the biochemical mechanisms and to develop new biological processes for complete destruction of these compounds.

Phase I: Should identify novel processes for the complete biodegradation of nitro-substituted contaminants including nitrobenzenes, nitrotoluenes, rdx, hmx, and tent that could lead to the development of a biotreatment system for contaminated soil or waste streams.

Phase II: Effort would be expected to implement the development and testing of such a system using contaminated material.

AF93-009TITLE: Improved Formulation of Fire Fighting Agents for Hydrocarbon Fuel FiresAF93-009TITLE: Improved Formulation of Fire Fighting Agents for Hydrocarbon Fuel Fires

CATEGORY: Basic Research

OBJECTIVE: Develop an environment benign AFFF firefighting replacement

DESCRIPTION: The current generation of aqueous film forming foams (AFFF) is not totally biodegradable. Life span of the agent when loosened into the environment is estimated to be over 25 years. AFFF is used extensively by dod firefighters in flightline operations to extinguish fires due to hydrocarbon fuels. AFFF is a superb extinguishing agent; however, there are problems associated with its effectiveness for extinguishing rolling fuel fires and its efficiency for securing the fire after its initial extinguishment. Additionally, there is a problem with the biodegradation of AFFF that has an ecological impact under current environmental legislation practices. It is desirable to develop an improved fire suppression agent for flightline firefightering that is also environmentally acceptable. The environmental performance characteristics of candidate surfacts chosen for the ability to spread across hydrocarbon fuels and suppress flame propagation under static and dynamic conditions will be established.

Phase I: Will establish the parameters for developing a fire suppression agent with the capability of extinguishing rolling fires in flight operations.

Phase II: Will develop a surfactant formulation that enhances the fire fighting capabilities of the present technology and invents a formulation which has less impact on the environment. This formulation must not have fluorosurfactants which contribute to environmental presistancy; however, the formulation must not sacrifice AF's superior fire knockdown capability.

AF93-010TITLE: Environmental Benign Anti-Icing Agents for Airfield UseAF93-010TITLE: Environmental Benign Anti-Icing Agents for Airfield Use

CATEGORY: Basic Research

OBJECTIVE: Develop biological anti-icing agents meeting air force standards, are cost effective, and have negligible environmental impact

DESCRIPTION: The ability to maintain ice-free aircraft and runways affects the safety and readiness of the air force flying mission. Maintaining compliance with environmental regulations also affects air force operations. All chemicals discharged to the environment have some level of impact. The major impacts of the current deicers are toxicity to aquatic organisms, the oxygen demand they impose in surface waters as they degrade, contamination of groundwater used for drinking water supply, and in the case of nitrogen containing deicers such as urea, the eutrophication of surface

waters by their nutrient loading. When many deicers such as glycols are degraded by microorganisms, oxygen is usually consumed; stated differently, a biochemical oxygen demand (bod) is exerted. In general, most deicing chemicals such as glycols and urea rapidly biodegrade in the environment exerting a high bod. The result is the depletion of oxygen in the aquatic environment and mortality of organism such as fish and invertebrates. An even more serious problem with urea is that it degrades to ammonia which is highly toxic to fish. Low temperatures and dilution from heavy runoff (snowmelt) during periods of use tend to minimize the immediate and future impact on surface waters. However, the potential for exerting bod remains until warm temperatures return and microorganism metabolism increases. In cold environments, the potential of surface runoff containing these chemicals to enter the groundwater is also high since they will not be degraded. Once the chemical is in the groundwater very little degradation will occur and the primary mechanism reducing the toxicity is dilution. Due to these problems many regulatory authorities are requiring airports to control these wastewaters for subsequent treatment or disposal. Runway deicing chemicals containing ethylene glycol and urea are being phased out of use in the air force due to the environmental impacts. In the environment there are organisms and plants that can withstand freezing by preventing critical fluids from forming ice crystals. This is analogous to anti-icing. Microorganisms that inhibit ice nucleation have been used to prevent frost from forming on fruit crops. These biological mechanisms that prevent the nucleation process that initiates the formation of an ice crystal(or the derived biological agents) may have application to runway anti-icing.

Phase I: Will provide proof-of-concept of developed anti-icer having similar ice preventing performance as urea and ethylene glycol without the environmental impact.

Phase II: Will provide a full-scale field demonstration of anti-icer, validate performance and ability to meet air force regulation 91-15, and obtain approval by air force materials laboratory, Wright-Patterson AFB, Oh.

AF93-011TITLE: Environmental Engineering ResearchAF93-011TITLE: Environmental Engineering Research

CATEGORY: Basic Research

OBJECTIVE: To develop new innovative ideas/concepts in the area of environmental engineering

DESCRIPTION: Environmental engineering research includes environmental behavior and fate of air force fuels and chemicals; hazardous waste minimization; treatment and pollution control; environmental chemistry; advanced pollutant monitoring technology; biodegradation of pollutants; and concepts to eliminate, substantially reduce, mitigate environmental consequences of future air force weapons systems

AF93-012TITLE: Deployable Refrigerant Recycle and Recovery UnitAF93-012TITLE: Deployable Refrigerant Recycle and Recovery Unit

CATEGORY: Basic Research

OBJECTIVE: Develop a refrigerant recycle and recovery unit for use with bare base environmental control units

DESCRIPTION: A field deployable refrigerant recycle and recovery unit is needed to minimize environmental damage as a result of releasing CFC refrigerants into the atmosphere during maintenance and repair of these units. The deployable unit will be compact and ruggedized to operate under a variety of adverse wartime conditions and should be capable of handling a variety of CFC and HFCF refrigerants. This effort will support both existing c100 environmental control units and a mobile heat pump currently under development.

Phase I: Deliverable will be a concept of operation to include details on suggested equipment design and construction, expected performance and durability, total expected weight, and assembly time

Phase II: A prototype will be constructed and tested for performance.

AF93-013TITLE: Bare Base PlanningAF93-013TITLE: Bare Base Planning

CATEGORY: Basic Research

OBJECTIVE: Produce software to aid engineers in bare base facility planning

DESCRIPTION: United States Air Force have typically conducted warfighting operations from a network of main and satellite operating base. However, US participation in regional conflicts outside the sphere of influence of existing us bases requires the rapid buildup of a warfighting airbase, typically called a 'Bare Base'. This program will require the development of personal computer based software to assist in the engineering layout of these bases. The design and layout of the Bare Base requires the assimilation and analysis of data from several sources of guidance. Without full consideration of this guidance, bare base planning may become time consuming and inconsistent. A user-friendly computer based methodology that will facilitate optimal bare base planning is needed. This program must include a listing of all facility and utility categories, the requirements that must be considered for layout of each facility and other concerns threat, terrain, weather, etc. That should be addressed in utility/facility layout. After addressing the layout requirements, estimates of facility size must be developed, general lists of what is necessary to build these facilities, and construction scheduling.

Phase I: Product does not have to include a graphical representation of the proposed layout.

Phase II: A detailed planning toolwill be required, which may include the ability to show a graphic representation of the base. This would include a deployment schedule of engineering materials for base construction, detailed facility size requirements and alternative siting plans.

AF93-014TITLE: Water Containerization/Distribution System for Arctic UseAF93-014TITLE: Water Containerization/Distribution System for Arctic Use

CATEGORY: Basic Research

OBJECTIVE: Develop a potable water containerization and distribution system for bare base installations in arctic environments

DESCRIPTION: Current potable water containerization and distribution systems are not designed for operation in extremely cold temperatures. These existing systems require intensive maintenance to ensure continued operation. A lightweight, mobile potable water storage and distribution system is required to provide continuous supply for up to 300 personnel (200 gal/day) in temperatures as low as -70 degree fahrenheit. Set up time for the system must be less than six hours.

Phase I: Deliverable will be a concept of operation to include details on suggested equipment types, materials of construction, and total expected weight and assembly time.

Phase II: Furnish cold weather operational and maintenance data on the suggested equipment and materials based on laboratory environmental operational testing, optimum equipment and material specifications and mobility packaging and assembly plans.

AF93-015TITLE: Structural Integrity of Intelligent Materials and StructuresAF93-015TITLE: Structural Integrity of Intelligent Materials and Structures

CATEGORY: Basic Research

OBJECTIVE: Characterize the interactions between sensors, actuators, and host materials in intelligent material systems.

DESCRIPTION: Considerable effort within the Department of Defense research community has been recently focused

on the development of intelligent materials and structures. These materials and structures have the ability to adapt to their environments through shape and/or material property modification. Applications of this technology include vibration and instability suppression, shape modification, and noise suppression. However, the complex microscale interactions between the sensors, actuators, and the host materials must be characterized before this technology can reach its full potential. Of particular importance is the understanding of the inherent geometric, material, and time-dependent nonlinearities within the intelligent material systems. Long-term usage of intelligent materials and structures may produce internal damage within the sensor/actuator. The fatigue life of these material systems needs to be further investigated. The understanding developed at the microscale will then be coupled with macroscale models to determine the optimum number of sensors/actuators that are necessary for a given application and the appropriate placements of these devices for optimal control. This project will address the mechanics that govern the complex interactions between sensors, actuators, and their inherent nonlinearities, providing a fundamental understanding that is needed for further development.

Phase I: Phase I will initiate the development of mathematical models for intelligent material systems.

Phase II: Phase II will further develop and verify these models through appropriate testing.

AF93-016TITLE: Organic/Polymeric Nonlinear Optical MaterialsAF93-016TITLE: Organic/Polymeric Nonlinear Optical Materials

CATEGORY: Basic Research

OBJECTIVE: To conduct research on developing organic/polymeric Nonlinear optically active material systems suitable for fabricating thin films or fibers for photonic applications.

DESCRIPTION: Research proposals are sought for developing organic/polymeric based material systems suitable for thin film or fiber processing. The material system must be nonlinear optically active (either second order or third order). In addition to possessing the necessary second or third order nonlinearity for device applications, the material system should be optimized for all necessary secondary properties suitable for device fabrication and utilization. These properties may include thermal stability, temporal stability, solubility, melting characteristics, low optical loss and compatibility with other materials needed in devices. The relationship between the target properties and the target device should be clearly delineated in the proposal. The chemistry approach to achieve the target properties should be clearly stated. All photonic devices/applications will be acceptable as research targets but special emphasis will be placed on optical beam steering, high frequency (hundreds gigahertz) phase modulation, and harmonic generation. The proposed research will be evaluated with emphasis on the innovativeness in studying the integration of existing knowledge of structure-properties relationships over the development of such relationships.

Phase I: Phase I results should establish the feasibility of the chemistry and the properties of the proposed material system.

Phase II: Phase II effort should be developing the material to a degree of maturity suitable for utilization in device research.

AF93-017TITLE: Self Designing Flight Control SystemsAF93-017TITLE: Self Designing Flight Control Systems

CATEGORY: Basic Research

OBJECTIVE: The development of a flexible implementation framework and methodology for a real-time, on-line, self designing flight control system.

DESCRIPTION: Aircraft flight control systems require compromises in peak performance, design difficulty, and implementation of resources. Present flight control design practices result in unduly restricted operational capabilities, a lack of flexibility, and an overall system whose performance is not sufficiently robust to unusual events such as failures and damage. The desire for peak performance under all conditions usually introduces gain scheduling to

transition between controllers. This gain scheduling is often complex and is rigid, and must be redesigned for each new circumstance. A continuous, real-time, on-line, self designing approach could yield the benefit of continuous optimal control. The optimization could be extended to the outer loop, such as guidance and trajectory control, so that inner and outer loops can be optimized together. This is crucial in applications such as hypersonic aircraft and missiles where the inner and outer loop cannot be separated. The self designing controller is applicable to a broad array of military as well as civilian applications, including robotics and autonomous vehicles. Advances in onboard computing power, sensor technology, adaptive materials, and nonlinear adaptive control theory have put the possibility of intelligent, high performance, self designing flight control systems within reach. The research goal is to understand how these advances can be integrated in a practical way to develop a self designing control system which continuously optimizes performance and which can accommodate events such as failures, anomalies, and damage, as well as maximize the aircraft flight envelope, maneuverability, and changing mission requirements. This will greatly enhance the aircraft lethality, survivability, configuration, and mission completion probability.

Phase I: Assess the feasibility, practicality, and the current technology limitations of the concept of a self designing controller. Develop a flexible, conceptual design framework, and the critical analytical and computational tools needed for a proof of concept for an onboard, real-time, on-line, self designing flight control system.

Phase II: Develop the design methodology for implementing a high level conceptual prototype of a self designing controller on derivative aircraft, and provide proof of concept on simulations. The structure of the designer should be demonstrated with the component modules in place and exchanging information for some streamlined, realistic scenarios.

AF93-018TITLE: Wide Bandgap Semiconductors for High Temperature ElectronicsAF93-018TITLE: Wide Bandgap Semiconductors for High Temperature Electronics

CATEGORY: Basic Research

OBJECTIVE: Develop new compound semiconductor materials suitable for the fabrication of high temperature electronics devices.

DESCRIPTION: Electronic devices and circuits capable of operation at temperatures in excess of current MIL SPEC limits (> 200 degrees C) offer significant advantages for atmospheric and space electronic systems. These advantages include the reduction of space, weight and power required for environmental cooling systems and increased reliability. The current focus is on Group IV-based (SiC, diamond) materials. The wide bandgap compound semiconductor materials, particularly III-V nitrides, offer alternative approaches. This program seeks innovative approaches to grow, characterize and use these and related materials. Specific attention must be devoted to high temperature electronic applications.

Phase I: The feasibility must be demonstrated for a particular material or device preparation.

Phase II: It is expected that the Phase II will carry the concept to the point of a characterization device.

AF93-019TITLE: Quantum Well and Superlattice IR Detector DevelopmentAF93-019TITLE: Quantum Well and Superlattice IR Detector Development

CATEGORY: Basic Research

OBJECTIVE: Develop quantum wells and superlattices of Group III-V, IV, and II-VI semiconductors for use in infrared detectors sensitive to wavelengths beyond 12 micrometers.

DESCRIPTION: Innovative concepts and demonstrations are sought for the development of quantum well and superlattice infrared detectors for wavelengths beyond 12 micrometers. Surveillance in the infrared part of the electromagnetic spectrum supplies crucial information to see objects which could otherwise escape detection. This program will develop IR detectors sensitive to wavelengths beyond 12 micrometers which will supply tracking

information on objects in space and at very high altitudes. Semiconductor materials and structures will be developed and optimized to perform at the highest temperatures consistent with maximum sensitivity for the assigned mission. Concepts using near normal incidence radiation are desired. The approach is to use designed materials to break the constraints that presently prevent access to important regions of the IR spectrum with affordable and reliable systems.

Phase I: Emphasizes novel detection concepts and may include research on the control of epitaxial growth processes, theoretical design of quantum well (QW) and superlattice (SL) structures, growth of the structures with appropriate layer thickness and doping, complete evaluation of the structures' optical, electrical, and magneto-optical properties, and design and processing of IR detectors and arrays.

Phase II: Will further develop the successful device concept, to include material characterization and device fabrication. Proof of principle will be demonstrated.
principle will be demonstrated.

AF93-020TITLE: Rare Earth Doped Semiconductor Devices and StructuresAF93-020TITLE: Rare Earth Doped Semiconductor Devices and Structures

CATEGORY: Basic Research

OBJECTIVE: Explore electronic and electro-optic device concepts and structures of technologically important semiconductors doped with rare earth impurities.

DESCRIPTION: The interest in rare earth or lanthnide-doped Group IV and II-V semiconductors has led to investigations involving luminescence, life-time, and electrical measurements, doping through numerous techniques (e.g., implantation, MOCVD, MBE), the fabrication of light emitting diodes, doping experiments in quantum well devices, and growth of semimetallic rare earth/Group V compounds on semiconductors. The interest continues in producing DC-pumped rare earth-doped solid state lasers, opto-electronic applications for silica and non-silica based fiber optics, impact devices, and the possible use of rare earth-doped devices for frequency standards. In recent years erbium-doped silica fibers have been successfully applied to amplify optical signals for transmission over long distances; applications which integrate the fibers with active elements on III-V and Group IV semiconductors are being considered. Other possible applications are rare earth ion laser materials, optically pumped by heterojunction emission in the host material. The key to many of the studies has been the proper incorporation of the rare earth ion into the semiconductor host and exciting the internal 4f-4f luminescence transition not only optically, but also electrically. There is a need to develop the capability to grow thick and high concentration rare-earth doped semiconductor layers so that fundamental experiments and device developments can be performed. For optoelectronic integration, the growth technique necessitates good control of heterostructures and epitaxial layers and an overall thick total layer combination.

Phase I: Research shall identify device concepts and device structures which will lead to relevant electronic and electro-optic applications. This phase will also allow for the further development of productive growth techniques for doping, with rare earths, technologically important Group III-V and Group IV semiconductors. Appropriate material characterization of the doped layers may be part of this phase.

Phase II: This would develop the fabrication procedures and demonstrate the proposed device structures.

AF93-021TITLE: Persistent Spectral Hole Burning Materials for Optical Memory and ProcessingAF93-021TITLE: Persistent Spectral Hole Burning Materials for Optical Memory and Processing

CATEGORY: Basic Research

OBJECTIVE: Grow rare earth or transition metal-doped host materials for persistent spectral hole burning applications.

DESCRIPTION: Many modern computer and processor architectures are limited in performance by insufficient degrees of freedom. Optical and opto-electronic approaches can ameliorate the resulting bottlenecks by providing

spatial parallelism and high temporal bandwidth. Employing optics' spectral breadth provides an alternative access to its temporal capacity; device researchers have exploited the spectral domain to implement both processing and memory. This extra dimension can be embodied in a material that supports spectral hole burning. That is, in a material whose absorption spectrum is in homogeneously broadened. Every known material that demonstrates spectral hole burning is inadequate in some of the various characteristics important for either memory or processing. Depending on application, features that can be important include: persistence time of spectral holes (in excess of 10 minutes is required for many memory applications; extremely low temperatures may be required); ratio of inhomogeneous to homogeneous linewidth (greater than 10,000 is desirable); optical absorption cross-section, and practicable dopant density of active species (near or exceeding 1%); and correspondence of the absorption wavelength band with the emission wavelength of a diode laser source (generally, between 700 and 1600nm). In addition, some mechanism for gating the simulation or relaxation of the atomic transition can enhance efficiency and prolong persistence. Current materials generally require extremely low temperatures to retain their persistent spectral hole burning character; although cryo-coolers to provide this environment reliability and efficiently are under development, materials that function at a temperature nearer to 77K than 5K are desirable. The materials of interest in providing these attributes comprise various host materials doped with rare earth elements or, conceivably, with transition metals. Opportunity exists for developing the capability to grow and supply these rare earth and transition metal doped hosts, many of which may require very high process temperatures. Various oxides such as yttrium aluminum oxide and yttrium silicate may be considered among candidates for active species host. Other prospects include semiconductor materials, diamond or other carbon structure, yttrium oxide, calcium tungsten oxide, and various halide salts. Indicated dopant densities of rare earth or transition metal active species exceeding 1% should be realized to warrant extended investigation.

Phase I: The objective is to identify, rationalize, and evaluate candidate persistent hole burning materials (very low temperature operating environment is allowable). Identification of the growth procedure capable of producing the material in reasonable specimen sizes and quantities, at reasonable cost, is expected (thin films on substrates may be considered). Prototype growth to demonstrate actual capability will provide a stronger basis for continued support into Phase II.

Phase II: The objective is to optimize growth procedures for selected materials, ensure reproducibility, and demonstrate controlled incorporation of dopants into the host material. Material selection will be made in consultation with the program manager. Material specimens will be made available for applications oriented characterization to the program manager and his designates in the Air Force Laboratories and supported by AFOSR programs.

AF93-022TITLE: HTS SQUID Magnetometry for NDI of AircraftAF93-022TITLE: HTS SQUID Magnetometry for NDI of Aircraft

CATEGORY: Basic Research

OBJECTIVE: Design, build and test an HTS SQUID magnetometry system to detect subsurface defects in aircraft.

DESCRIPTION: Air Force logistics operations have several major priorities relating to the detection of subsurface structural defects in the metallic skin of its aging aircraft. At the present time there is no existing technology to detect such defects reliability in flight-line operations. Present commercial eddy-current techniques have insufficient sensitivity to give unambiguous information on the structural integrity of aircraft at depths of about one inch below the surface. Yet, small cracks and corrosion are often present in older planes at such depths, especially near rivets and similar fasteners. Recent research with helium temperature (LTS) SQUID magnetometry in a laboratory environment has indicated that the increased sensitivity of this instrumentation (down to very low frequencies) enables it to detect even very small cracks at depth. While it would be difficult to adapt an LTS system to a flight-line environment, it should be possible now to develop a compact, portable HTS SQUID system which can be oriented in any direction. It is only recently that HTS SQUIDs and coupling coils operating in the range of liquid nitrogen temperature could be manufactured reliably with sufficiently high sensitivity. At the same time a new generation of reliable, efficient, small-scale cryocoolers has emerged for operation down to 65 degrees K. By combining a cryocooler (or small liquid nitrogen dewar that can be used in any orientation) with HTS SQUIDs and other HTS elements, it should be possible to build a small, self-contained unit for routine aircraft maintenance operations and with a sensitivity to detect small cracks

at a depth of about one inch in aluminum structures.

Phase I: Phase I will include the design of the complete system based upon information obtained from Air Force logistics personnel and aircraft manufacturers, and upon investigation of HTS SQUIDs, HTS coil configurations and cryogenic systems.

Phase II: Phase II the complete system will be constructed, assembled and tested on standard defect structures, as well as on Air Force equipment.

AF93-023TITLE: Human Systems/Subsystems ResearchAF93-023TITLE: Human Systems/Subsystems Research

CATEGORY: Basic Research

OBJECTIVE: Develop innovative human-related systems or subsystems for aerospace applications.

DESCRIPTION: Proposers may submit ideas to enhance man's capability to function effectively and safely as an integral part of Air Force systems and military operations while increasing mission success. This includes the following: 1) human factors engineering, such as methods improving human/machine and human/computer interfaces or enhancing human physical or cognitive performance; 2) personnel protection/life support, such as crew escape in high Mach environments; 3) chemical/biological warfare defense, such as advanced personal protection and detection, identification and warning systems; 4) occupational/environmental hazards, such as identification of and protection from toxic materials and electromagnetic radiation; 5) personnel training and simulation, such as new computer-based technologies that improve the effectiveness and reduce cost of training systems; 6) aeromedical support, such as medical risk assessment and medical data collection, analysis and management; and 7) logistics support, such as logistics design and maintenance aids. Ideas are solicited that affect any or all of the operations, maintenance, and support roles of Air Force personnel.

AF93-024TITLE: Improvements in High-Altitude Life Support Equipment and Diagnostic TechnologyAF93-024TITLE: Improvements in High-Altitude Life Support Equipment and Diagnostic Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop low resistance breathing system components; advanced decompression/denitrogenation computer systems; and ebullism protection garmentry.

DESCRIPTION: Specific areas include the following: (Specify subtopic by letter)

a. Flow resistance offered by current USAF aircraft oxygen systems limits the rate at which breathing gas is delivered to the crewmember. High breathing resistance adds work stress, discomfort and distraction to an already high workload, stressful, flight environment. High inspiratory resistance may produce reduced G-tolerance by reducing the effectiveness of anti-G respiratory straining maneuvers. It may also contribute to the episodes of hypoxia and abnormal respiratory gas exchange. Identification of the flow resistance contributed by each of the component parts of currently deployed oxygen systems will enable us to identify the components which are the best candidates for redesign. Current systems fall short of meeting the standards set down by the Air Standardization Coordinating Committee for aircrew breathing systems. Suggested design changes and prototype low resistance components are needed to advance future development of these systems toward meeting these standards. Phase I efforts will identify the flow resistance in each of the components and suggest design changes for the components which are significant contributors to breathing resistance. Phase II will produce a brassboard low-resistance breathing system, from the regulator to the oronasal mask, for standard aircrew operations.

b. Develop advanced decompression/denitrogenation computer systems for real time and predictive decompression sickness risk assessment. High-altitude exposures in aircraft, hypobaric chambers, and with extravehicular activity (EVA) in space result in an inherent risk of decompression sickness (DCS). In the past, general

guidelines for safer altitude exposures have been developed through costly time-consuming studies, each specific to unique altitude exposure scenarios. The results of these studies are often difficult to apply to new altitude requirements. Therefore, new, time-consuming studies must be undertaken. Rapidly changing technology in aircraft design dictates improved decompression risk assessment capability. Data bases exist for the development of a standardized altitude decompression/denitrogenation model, such as exists on altitude decompression computers. These computers are needed for both real- time DCS risk information as well as DCS risk predictive capabilities. Utilization of such hardware is anticipated in aircraft cockpits, or hypobaric chamber control stations, in EVA suits, as high altitude mission planning computers. Phase I will develop the software program for the decompression model, and Phase II will provide a hardware prototype for further operational development.

c. Operations in both advanced, high-altitude aircraft and in space have the potential for accidental human exposure to hypobaric environments in which the ambient pressure is less than the vapor pressure of water. Under such conditions the water in human tissues may vaporize, causing considerable expansion of the affected tissues. Body containment garments, in combination with positive pressure breathing systems, have been suggested as one possible means of protecting aircrew in these environments. Such a garment would be p73 designed to passively restrict the swelling of enclosed tissues in the event of accidental depressurization. The envisioned garment, which would be incorporated into the aircrew clothing ensemble, should be lightweight, comfortable, and allow adequate freedom of movement. Phase I efforts will identify and evaluate existing and emerging garment materials and conduct proof of concept demonstrations with the most promising materials. During Phase II a variety of prototype garments will be designed, fabricated and tested to produce a design specification suitable for full-scale development efforts.

AF93-025TITLE: Behavioral Chronopharmacological TechnologyAF93-025TITLE: Behavioral Chronopharmacological Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop a lightweight, durable means to record chronophysiological activity and control active transdermal drug infusion.

DESCRIPTION: Specific areas include the following: (Specify subtopic by letter)

a. Many stressful events encountered by military personnel are manifested in the body by physiological events. For example, cortisol is released to generalized stress; melatonin levels may indicate the extent of circadian dysrhythmia; and glucose measures suggest rate of energy and oxygen utilization. Since time and techniques are usually limited in field assays, measures are sought which will rapidly provide a reasonably close approximation of more sophisticated measures. Although test kits are available for many of these assays, they involve sampling from blood. Since blood assays are invasive and require extensive preparation and handling, they are unacceptable. Phase I will involve a monitoring system that uses saliva or perhaps urine or sweat to register more than one physiological parameter. Phase II will adapt the size and durability of the system for operational use. Such a device must allow operational military personnel to quickly determine and document their level of physiological stress (fatigue or otherwise). The device would have civilian applications in that it would allow patients to better administer their medications with greater awareness of their current physiological state.

b. Numerous life-threatening events exist for military personnel that could be attenuated with accurate chemical intervention. For example, the biological damage produced by nerve agents can be reduced by precisely timed pre-treatment drugs. Similarly, incapacitating fatigue can be alleviated with stimulants. Timing the bioavailability of these medications to the threat is crucial to their effectiveness. A distinct advantage of a user-controlled active patch infusion system is that is would allow the user to speed up, to slow down or to terminate drug administration if the threat no longer or never existed; these options are not available with oral administration. For example, a fatigued pilot may find it necessary to ingest a stimulant to complete the mission. Rather than experiencing the side effects associated with the brief, peak plasma concentrations after an oral stimulant bolus, a square wave-like steady state could be achieved more rapidly by a patch infusion system. Phase I will involve an infusion device that uses electrophoretic or chemical means to actively promote the transdermal administration of a wide variety of defensive drugs. It is distinguished from the passive diffusion systems found on most patch devices which oftentimes requires excessively

large patches because of the slow absorption of some molecules. Phase II will involve a system designed for operational use that would be smaller, more durable and would allow for the timed administration of preventive medication closer to the onset of a threat and the termination of the infusion at any time. Civilian applications would also exist since it would allow patients better control over the steady-state kinetics of their medications. For example, older people with difficulty in remembering to take their medications would benefit because the slow, steady drug levels or the timing of multiple drugs could be automatically administered by a small microchip-driven system.

AF93-026TITLE: Crew Protection SystemsAF93-026TITLE: Crew Protection Systems

CATEGORY: Exploratory Development

OBJECTIVE: Enhance crew protection systems in Air Force operational environments.

DESCRIPTION: Specific areas include the following: (Specify subtopic by letter)

a. A requirement exists for effective voice communications, crew safety, and human performance in environments that are based on natural, intuitive interfaces using innovative abilities and requiring no learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, reduce workload and fatigue, and improve personal safety. These intuitive interface technologies include but are not limited to: 1) auditory system modeling and neural network for robust signal processing of speech; 2) digital audio technology to allow integration into aircraft systems; 3) voice communications countermeasures/ counter-counter measures; 4) noise-induced hearing loss sound protection; 5) active noise reduction; and 6) 3-Dimensional auditory display for spatial awareness and communications. Phase I efforts would provide an assessment of the state-of-the-art and an approach to develop an appropriate intuitive interface technology. Phase II efforts would provide a demonstration and validation of the intuitive interface technology.

b. Provide concepts for human control of robots in hazardous environments that combine the cognitive abilities of the human with the robustness and physical capabilities of robots. Feedback or human operator awareness of the robotics work environment expands the mission capabilities. Challenges are to develop quality force feedback from the robot to operator via exoskeleton and fine manipulation of human-sized robotics hands. Phase I effort should explore test methods and criteria for operator - robot interfaces and sensory feedback specifications or investigate novel feedback mechanisms. Phase II products should be small force feedback exoskeleton that incorporate small volume, high efficiency controlled actuator mechanisms.

c. A requirement exists for an analytical method to quantify the aerodynamic and inertial forces acting on a crewmember during emergency escape from ejection seat equipped aircraft. Efforts to improve open ejection seat performance by minimizing windblast injuries have led to various seat-mounted design concepts. Wind tunnel testing has been our primary technique for evaluating these systems, but this method can be expensive and time-consuming. Computations Fluid Dynamics (CFD) has typically been used to study the forces acting on a streamlined, aerodynamic body. Application to a bluff body ejection seat/crewmember combination has not been explored. By using CFD to evaluate different windblast protection concepts, we could essentially conduct trade studies on several windblast protection systems prior to conducting an extensive wind tunnel test program. Phase I will produce an assessment of the current state-of-the art in CFD development to determine the best approach to develop the codes necessary to predict the aerodynamic loading and aerothermal heating of an ejection seat/crewmember combination. At a minimum, CFD must allow us to predict the aerodynamic loading on the crewmember's arms, legs, and head/neck and develop an overall surface aerothermal loading profile for the crewmember. If CFD cannot currently be applied to the emergency ejection (non-rigid, bluff body) scenario, the contractor must identify and outline the CFD development efforts necessary to use CFD as a computational aid for escape system h83 development. Phase II will identify the development efforts and methodology necessary to demonstrate and validate this computer simulation capability. It will conclude by demonstrating and validating this simulation technique.

AF93-027TITLE: Augmented Crew Perception for Precision StrikeAF93-027TITLE: Augmented Crew Perception for Precision Strike

CATEGORY: Exploratory Development

OBJECTIVE: Develop designs for imagery delivery and integrating automated imagery interpretation into AF weapon systems.

DESCRIPTION: Develop technology to enhance the human perception process with a) alternative and enhanced helmet-mounted display technology and b) design strategies for integrating automatic target cueing/recognition with crew perception and situation awareness. (Specify subtopic by letter)

a. Develop an alternative to cathode ray tube technology which will overcome current limitations in the image-forming element of helmet-mounted displays. Size, weight, power, brightness, contrast, and resolution are all critical issues. Phase I will result in a notional design based on a well- referenced review of existing literature and on realistic estimates of candidate display technology potential. Phase II will develop a specific design and, if possible, develop a working prototype (not necessarily in scale) of the design.

b. Develop innovative strategies to the man-machine interface between aircrew members and sensor systems which contain automatic target cuer/recognizers. These strategies should be based on state-of-the-art cognitive science and be consistent with the evolving capabilities of image processing technology. The notional design delivered for Phase I should not interfere with other aircrew duties (i.e., flying the aircraft) and should provide the lowest possible error rates (misses and false alarms). Phase II should test this interface in simulation to determine whether it performs adequately and, based on the simulation results, suggest further enhancements and refinements.

AF93-028TITLE: Passive Optometer for Night Vision Devices and Helmet- Mounted DisplaysAF93-028TITLE: Passive Optometer for Night Vision Devices and Helmet- Mounted Displays

CATEGORY: Exploratory Development

OBJECTIVE: Design, develop, and test a light-weight non-obtrusive optometer.

DESCRIPTION: This requirement is for needed data on accommodation effects of imaging displays currently being researched at this division. Develop a simple, light-weight, non-obtrusive optometer that will measure accommodative responses in a continuous passive manner. Upon completion of optometer development and test activities, the system will be used by Laboratory scientists to measure accommodation responses of individuals under a variety of test conditions in conjunction with the use of night vision goggles, fiber optic helmet-mounted displays, and real image displays. The measures obtained from the optometer shall be used to gain insight into size/distance judgment biases associated with the use of these displays. Additional judgment experimentation is planned in which the optometer will be used in a stand-alone fashion to gain further understanding of the criticality of accommodation shifts in producing accurate judgments of target size and distance. Phase I will result in a design proposal for a simple, light-weight non-obtrusive optometer that could be used to measure accommodation responses in a continuous passive manner from operators using helmet-mounted devices. These devices include night vision goggles, fiber optic helmet-mounted displays, and real image displays. Phase II will result in the development, test and evaluation of the optometer proposed in Phase I. Development of this device will be of interest to DoD and to other organizations such as NASA and FAA.

AF93-029TITLE: Gaming, Speech Processing, and Simulations for Intelligent Training SystemsAF93-029TITLE: Gaming, Speech Processing, and Simulations for Intelligent Training Systems

CATEGORY: Exploratory Development

OBJECTIVE: Develop functional prototypes which demonstrate gaming strategies, speech processing, and simulation authoring for intelligent training.

DESCRIPTION: Gaming strategies, speech processing, and interactive simulations are emerging new technologies which can greatly enhance the effectiveness of instructional computing systems. The following requirements reflect Armstrong Laboratory's commitment to optimizing the use of these technologies in intelligent training systems applications. (Specify subtopic by letter)

a. The successful application of artificial intelligence in the instructional arena has produced automated instructional systems with the capability to generate literally hundreds of hours of instruction. For many kinds of complex skills, performance continues to improve over very long learning curves. However, it is difficult for trainees to maintain motivation and focus in the long run, especially since performance improvement per time increment goes down significantly after initial learning occurs. One approach to generating and maintaining motivation is to introduce fun and competitive games into the training regime. These games might involve competition against a computerized opponent, against other humans, or against oneself. Phase I proposals for this topic should build a prototype Intelligent Tutoring System in a domain of mutual interest to the respondent and the Air Force, where the intelligent tutoring system uses a gaming approach to providing practice. Phase II projects would expand this prototype to a full-scale instructional system. Appropriate domains for consideration might include, but are not limited to, air traffic control, electronic troubleshooting, mathematics, and orbital mechanics.

b. Develop a flexible and efficient speech processing capability for use in conversational tutoring systems. Level of interactivity is a critical aspect of intelligent training systems. Speech recognition and generation is a new technology that can greatly improve interactivity in computer-based instruction by making student-system interactions more natural and conversational. The primary purpose is to enhance student interactivity in computer-based learning environments. Phase I will result in a set of specifications and an initial prototype which can be trained to recognize 100 words by an arbitrary speaker in less that ten minutes. Phase II will produce a fully operational speaker-independent prototype for speech recognition and processing in training applications. The Phase II prototype should be trainable to a vocabulary of 500 words in five minutes.

c. Develop a cost-effective simulation authoring capability to augment efforts to develop an intelligent instructional design advisor which can be used by subject matter experts who have had little formal training in instructional technology. Phase I will result in a concept paper with a set of specifications and an initial prototype which allows a computer-literate subject matter expert to create an object-oriented qualitative simulation in a technical training domain of mutual interest. The Phase I prototype will contain a library of a least 100 objects. Phase II will produce a fully implemented prototype which can run in an 80386/80486/80586 environment. The Phase II prototype will incorporate a library of 500 objects and provide on-line assistance.

AF93-030TITLE: Computer-Based Assessment of Pilot Aptitude and PersonalityAF93-030TITLE: Computer-Based Assessment of Pilot Aptitude and Personality

CATEGORY: Exploratory Development

OBJECTIVE: Develop a computer-administered test battery that predicts pilot performance in combat scenarios.

DESCRIPTION: This requirement is for a computer-administered test battery that measures aptitudes and personality traits related to effective performance as a combat pilot. The Armstrong Laboratory has developed and is now implementing the Basic Attributes Test, which will be used to select Air Force pilots. Classification, i.e., aircraft assignment, will be based on individual preference, performance in undergraduate pilot training, and aircraft availability. We want to explore the possibility of a new test battery that could be used in the classification process. In particular, there is a need to identify and measure the aptitude and personality traits that predict which pilots will develop the highest levels of combat skills. (Specify subtopic by letter)

a. This requirement is for the aptitude component of the test battery to focus on the perceptual motor abilities, attentional capacity and processes, information coordination, processing speed, decision making under stress, spatial orientation, situational awareness and other performance abilities that a pilot must use in fighter and attack aircraft. Phase I of this effort will result in a set of recommendations concerning the content, i.e., psychological constructs to be measured, and design of a new human performance abilities test battery. The test battery design should build on and

extend (not duplicate) the Basic Attributes Test. Phase I will also demonstrate the feasibility of the proposed test battery in the form on one executable performance test that measures one of the proposed psychological constructs. Phase II of this effort will result in a computerized test battery that has undergone initial administration, reliability analysis, and factor analysis. Proposals should assume that the battery will be hosted on a 486/33 microcomputer. Additional equipment to be used as input devices, e.g., joysticks and rudder pedals, may be proposed if necessary for the measurement of a particular psychological construct.

b. This requirement is for a computer administered battery that uses state-of-the-art developments in computer technology and psychological theory to measure personality traits associated with effective performance as a combat pilot. Past efforts to include personality measures on screening batteries such as the Basic Attributes Test have consisted of traditional self-report personality inventory items and indirect assessments through performance of a task designed to elicit particular types of behavior, such as risk-taking or decisiveness. To date, the results of these efforts have not fully utilized the potential of computer-administration such as stratified adaptive testing, opportunities for response verification, presentation of dynamic stimuli, and recognition of patterns of personality characteristics using neural network analysis. Computer-administration has several advantages, because of computational speed and also because of the use of sophisticated algorithms and artificial intelligence. Using fairly simple algorithms, for example, the computer can check for random responding and evidence of response set while the subject is taking the test. Items can then be readministered as necessary. At a more sophisticated level, the computer can iteratively develop a model of the subject's personality, that can be refined and elaborated through presentation of appropriate stimuli in a dynamic, flexible format. In a sense, the advent of p73 computer-based personality measurement combines the advantages of an in-depth interview by a subject matter expert with the scientific rigor of a structured inventory. Phase I of this effort will result in specifications for candidate measures. Phase I will also produce sample items of inventory measures and sample demonstration forms of proposed performance-based tasks. Phase II will result in a battery of personality tests suitable for administration on a 486/33 microcomputer.

AF93-031TITLE: Environmental Technology - ComplianceAF93-031TITLE: Environmental Technology - Compliance

CATEGORY: Exploratory Development

OBJECTIVE: Develop sampling/analysis techniques to improve environmental and occupational health programs.

DESCRIPTION: Specific areas include the following: (Specify subtopic by letter)

a. Air Force bases are required by OSHA to monitor work areas for asbestos fibers. The present method requires that filters used to collect air samples be cut into a small wedge and prepared for fiber counting. The fiber count is manually done by phase contrast microscopy as directed by NIOSH 7400 method. The wedge must be moved at random 100 times and fibers counted in an 0.0785 mm calibrated area. The method is labor intensive and requires much time. Armstrong Laboratory requires an automated method to count asbestos fibers as per NIOSH method 7400. It is proposed that this be accomplished with a video analyzer and high resolution video camera. Image analysis could be done by computer to differentiate between asbestos and nonasbestos fibers. A multi- slide stage could be used for unattended counting. Phase I will be to investigate the possibility of this approach. Phase II will be to assemble and test such equipment to perform the automated analysis. This procedure will be of interest to other federal agencies such as the EPA.

b. Current methodologies of environmental analyses for organic species, such as pesticides and herbicides, generate large volumes of hazardous waste solvents which have characteristics that make them hazardous, cause storage and disposal problems, and cause potential exposure risks to analysts. Current approved technologies include extracting environmental samples with large amounts of organic solvents and concentrating the extracts into a small volume. Phase I will demonstrate viable alternate analysis techniques for pesticides and herbicides that drastically reduce the amount of waste solvents generated. Such techniques may employ some sort of solid phase extraction. Phase II will develop the best of those demonstrated methodologies and provide recommendations to appropriate federal agencies for approval of such methodologies as acceptable methods.

c. Current techniques for identification of organic components in hazardous waste solutions are very time

consuming. Analysis time of these complex samples becomes a problem when there are many samples to be analyzed. Bases can only legally store these wastes for a short period of time and need quick chemical analyses to characterize the waste before disposal. Phase I will show the development of such instrumentation is possible, and demonstrate such quick and sensitive analyses. Phase II will develop such instrumentation, and implement the methodology so that the usable system will handle standard check solution as well as actual base-waste samples.

AF93-032TITLE: High Power Radiofrequency Energy to Separate Types of Radioactive WasteAF93-032TITLE: High Power Radiofrequency Energy to Separate Types of Radioactive Waste

CATEGORY: Exploratory Development

OBJECTIVE: Develop apparatus for separating uranium and transuranic constituents from relatively large volumes of contaminated soil.

DESCRIPTION: Presently the Air Force, and the other services, generates large quantities of depleted uranium-contaminated sand as a result of munitions testing. In the event of a weapons-related accident/incident, large quantities of soil contaminated with transuranics, in particular plutonium, could be generated. With disposal costs for these wastes increasing at an ever faster rate (expected to reach $500.00 per cubic foot or more by 1994), it is imperative that the services reduce the volume of radioactive waste generated to the maximum extent possible. One method which shows some promise of separating depleted uranium from sand is a method (Patent Number 4,894,134) which uses high power, variable frequency RF energies in selective or rarefied atmospheres to eliminate unwanted impurities from a variety of nonconductive base materials. Phase I would be to explore the feasibility of applying this method to large volumes of sand/soil contaminated with depleted uranium and possibly plutonium. Phase II would be to construct a small-scale prototype industrial process utilizing this technology. Phase III should result in a production model system which can be moved from site to site depending on the need.

AF93-033TITLE: Collection and Display of Aircraft Information for Environmental Noise AnalysesAF93-033TITLE: Collection and Display of Aircraft Information for Environmental Noise Analyses

CATEGORY: Exploratory Development

OBJECTIVE: Develop automated collection of aircraft data for operations around airbases.

DESCRIPTION: The Air Force has installed Secondary Radar Systems named Programmable Indicator Data Processors (PIDP) at 50 of the busiest Air Force bases with plans to install these at another 34 bases. This system gives the Air Traffic Controllers (ATCs) position/airspeed information on all flying aircraft within the controllers' airspace. Currently, there is no interface of this system to any recording device. If the spatial position information provided by the PIDP could be synchronized with the Identification Friend or Foe (IFF) or Beacon code and time of event, and downloaded to a personal computer, software could then be developed to automatically identify the aircraft type and translate positional data directly to a microcomputer for subsequent analysis. This database could be used to derive nominal aircraft flight ground tracks, flight profile altitudes, airspeeds, and track dispersions. This information along with operational statistical data could be input to BASEOPS, a computerized operations input module for airbase noise analysis. Such an automated aircraft operational data record would significantly improve the reliability of inputs presently used for the Environmental Impact Analysis Process (EIAP) and the Air Installation Compatible Use Zone (AICUZ) program. This same aircraft operational database could also be used for particulate and gaseous emissions reporting required in air quality analyses. This new capability would certainly lead to more accurate and defensible noise and air quality assessments that are presented to the public. This topic is intended to provide an opportunity for the proposer to submit ideas directed towards collection of accurate aircraft operations information around airbases for input to environmental analyses. This topic covers areas from hardware interface to a personal computer to statistical analyses of operations count, flight track and altitude dispersions to incorporation of final results into environmental

analysis models. A Phase II effort would result in a field tested, fully working computer program and hardware interface that would be used for aircraft operations data collection for compatible land use planning purposes and for either/both noise and emissions environmental impact analyses.

AF93-034TITLE: CaF2 (EU) Detection and Computer Interface for Radiation DetectorsAF93-034TITLE: CaF2 (EU) Detection and Computer Interface for Radiation Detectors

CATEGORY: Exploratory Development

OBJECTIVE: Develop USAF Radiological Health Laboratory designed probe and computer interface for non-ionizing radiation temperature measurements.

DESCRIPTION: Proposals may be submitted against the specific requirements indicated below. (Specify subtopic by letter)

a. In 1976, personnel assigned to the USAF Radiological Health Laboratory at Wright-Patterson AFB, Ohio, (now Armstrong Laboratory at Brooks AFB TX) designed and produced a calcium fluoride, europium doped, (CaF2(EU)) based scintillation probe for use in making field measurements of low energy radiation from the 17 keV L X-rays from plutonium and the 60 keV gamma rays from americium-241. Several of these probes were subsequently produced. These original probes are still in use, and have proven to be highly sensitive and rugged under all types of field conditions. The goal of this research will be to redesign these probes using state-of-the-art electronics and thereby improve the overall detection sensitivity of the probe. Phase I will develop a specific proposal for improving the original design (original specifications available from AL/OEBSC). Phase II will be to construct and test a prototype of the proposed design using as a minimum ANSI N42.17A standards, and if testing is satisfactory, provide 20 complete probes for use by the Air Force Radiation Assessment Team.

b. Although a probe and system for temperature measurement in Radiofrequency Radiation (RFR) fields are commercially available, there is no interface to standard laboratory computers. The computer interface will provide an easily implemented method for accurate temperature measurements which are used for two purposes in RFR experiments: 1) The temperature of the preparation is, of course, needed to document experimental conditions 2) Initial temperature increase at the onset of RFR is used to determine specific absorption rate. The interface will be constructed using standard hardware components and have associated software written for its use. It is anticipated that the connection to the probe will be an appropriate analog-to-digital converter. However, a search must be performed to identify devices which facilitate communication with IBM PC compatible computers. Phase I will be a search for appropriate technology to allow computer interface between commercially available temperature measurement systems and standard computer systems. Initial designs will consider direct connection of a converter to the computer, such as the Intersil ICL7109. The search will also identify the most appropriate sensor board for a PC expansion slot. Phase II will produce an interface between temperature probe and computer. This product would be commercially viable in Phase III. The market would be all medical workers and scientists performing thermal measurements in radiofrequency fields, possibly 10-50 thousand if the system is used for medical diathermy.

AF93-035TITLE: Command, Control, Communications and Intelligence TechnologiesAF93-035TITLE: Command, Control, Communications and Intelligence Technologies

CATEGORY: Exploratory Development

OBJECTIVE: Develop Innovative concepts for increasing warfighting capabilities of the Air Force Command, Control, Communications and Intelligence (C3I) systems.

DESCRIPTION: Proposals may address any aspect of AF C3I systems not specifically covered by other SBIR topics. Areas of interest include, but are not limited to C3I concepts for: fixed and mobile command centers; tactical operations; special forces operations; AF ground based or airborne early warning systems; AF mobility issues; mission

support system (MSS) planning tools; electronic countermeasures; advanced communications systems and innovative data fusion schemes for C3I sensors. This topic offers great flexibility for proposers to offer solutions to AF C3I problems. Proposal titles must reflect the specific C3I area being addressed.

Phase I: Phase I should accomplish the initial feasibility analysis and develop an implementation and demonstration plan for phase II.

Phase II: Phase II should accomplish a prototype development and/or demonstration.

AF93-036TITLE: Innovative Approaches to Logistics SupportabilityAF93-036TITLE: Innovative Approaches to Logistics Supportability

CATEGORY: Exploratory Development

OBJECTIVE: Develop innovative concepts, models and diagnostic tools to advance the logistics supportability of Air Force C3I systems.

DESCRIPTION: There are many opportunities for innovative supportability concepts. Some of these opportunities run concurrently with the development of technologies such as photonics, GaAs, InP etc. Others are to be found by interrelating existing parameters so that new algorithms emerge which more accurately predict supportability of Air Force C3I systems. Proposals to this topic may address any aspect of logistical support to Air Force C3I systems not specifically covered in other SBIR topics. Of specific interest at this time are:

a. The development of supportability parameters (Si-inherent supportability, Sa-achieved supportability, So-operational supportability) and a supportability model to predict the support status of an Air Force C3I system, similar to availability parameters (Ai, Aa, Ao).

Phase I: Develop, define and relate meaningful supportability parameters in an algorithm, preferably a simple algebraic formula, to predict supportability status of a C3I system.

Phase II: Refine algorithm and demonstrate application to various Air Force C3I systems.

b. Development of diagnostic tools capable of identifying and/or predicting failures in electro-optic and photonic systems (excluding the optical fibers themselves).

Phase I: Identify key failure mechanisms in electro-optic and photonic systems/subsystems and propose concepts for diagnostic tools.

Phase II: Develop and demonstrate prototype diagnostic tools.

AF93-037TITLE: Innovative Approaches to Physical Security SystemsAF93-037TITLE: Innovative Approaches to Physical Security Systems

CATEGORY: Exploratory Development

OBJECTIVE: Develop advanced non-intrusive biometric sensors and innovative communication schemes for relocateable security systems.

DESCRIPTION: Innovative approaches are sought to two aspects of physical security.

a. Advanced non-intrusive biometric sensors are needed for access control applications which provide faster, more accurate identification of individuals and require less user interface.

b. Innovative communication schemes are sought which allow individual sensors of a relocateable security system to communicate between themselves and a remote monitoring site without the need for hard wires or fiber optic interconnects. Concepts must provide for reliable, jam resistant communication.

Phase I: During phase I a feasibility analysis of the proposed concept should be accomplished and summarized in a final technical report.

Phase II: During phase II a prototype should be developed and demonstrated.

AF93-038TITLE: Electromagnetic Shielding for Electronic Equipment SheltersAF93-038TITLE: Electromagnetic Shielding for Electronic Equipment Shelters

CATEGORY: Exploratory Development

OBJECTIVE: Develop more efficient electromagnetic shielding concepts for new composite electronic equipment shelters.

DESCRIPTION: Military communications and electronic equipment contained in tactical shelters requires protection from potentially damaging electromagnetic pulse (EMP); electromagnetic interference (EMI); and disruptive radio frequency interference (RFI). Shielding serves a multipurpose function by protecting enclosed equipment from external sources of EM fields while containing emanations from the equipment itself. The shield must attenuate the undesired signals to an acceptable level and electrical continuity throughout the shield must be maintained. Presently, there are efforts to produce a next generation shelter using composite materials which still require EM protection. Therefore, designs must be investigated to provide electrical continuity throughout the shelter. Techniques and materials for establishing EM shielding in composite shelters, improved and more reliable EM gaskets installed at any seam such as a door opening, and techniques of mating the gasket to the shelter EM shield need to be developed. Of particular concern will be to provide shielding at joints, corners and seams, as well as designing concepts that will provide protection at all frequencies of concern.

Phase I: During phase I it is expected that existing materials and/or new material designs, as well as fabrication techniques, to assure required shielding effectiveness will be explored. Alternative gasket designs and mating techniques will also be explored and estimated cost and performance of concepts as applied to an S-280 size shelter will be summarized in a final report.

Phase II: During phase II it is expected that prototype shelter panels, joints, corners and door assemblies incorporating the concepts identified in phase I will be fabricated and tested for EM shielding effectiveness. Prototype gasket designs will be fabricated and mated to the prototype door assembly for life expectancy testing and EM shielding effectiveness.

AF93-039TITLE: In-Transit Visibility TechnologiesAF93-039TITLE: In-Transit Visibility Technologies

CATEGORY: Exploratory Development

OBJECTIVE: A system-of-systems capable of tracking a specific individual or piece of cargo down to its current location.

DESCRIPTION: Air Mobility Command (AMC) has a need to track the real time status and location of planned, in-transit and completed airlift cargo and passenger movements. For in-transit situations a need exists to show aircraft tail number, current location and ETA (if airborne). Proposed systems should: (1) consolidate planned and actual force movement information from defense transportation shipping agencies, unit level transportation offices, mobility and unit move sources; (2) combine DOD wide transportation data with AMC command and control actions; (3) maintain a consolidated track record (both classified and unclassified) of force movement, transportation and C2 actions; (4) make the consolidated information quickly and easily available, in real time, to any AMC user; (5) Provide a single user friendly terminal that performs all navigation tasks through the C2 and transportation communications-computer systems. The User simply chooses the application needed and will no longer need to access multiple terminals and systems to get the information to do their job.

Phase I: Develop a key component of at least one of the tasks listed above.

Phase II: Develop and demonstrate prototypes of key hardware and/or software elements.

AF93-040TITLE: Cost Benefit Analysis Tool for C4 Information ModellingAF93-040TITLE: Cost Benefit Analysis

Tool for C4 Information Modelling

CATEGORY: Exploratory Development

OBJECTIVE: Develop a cost benefit analysis tool for C4 systems.

DESCRIPTION: Currently, Electronic Systems Center (ESC) lacks the methodology and tool sets needed to perform a cost benefit analysis of potential alternative solutions of Air Mobility Command's (AMC) command, control, communications and computer (C4) needs. A structured functional/economic methodology and supporting tool set needs to be developed which uses the information modeling data ESC has available to perform cost benefit analysis. The proposed tool must consider the rate of information exchange at execution nodes, be able to compare costs between systems and their benefit to the user's functional requirements, and accomplish functional/economic cost comparisons between possible solutions. Such a tool would be useful to any organization (private or federal) that deals with large quantities of computer managed information.

Phase I: Develop a functional/economic methodology to perform C4 cost benefit analysis and the top level implementation algorithms.

Phase II: Produce prototype software tool to fully implement the methodology developed in phase I.

AF93-041TITLE: Application of Artificial Intelligence and Neural Networks to Command CentersAF93-041TITLE: Application of Artificial Intelligence and Neural Networks to Command Centers

CATEGORY: Exploratory Development

OBJECTIVE: Develop an artificial intelligence decision aid to support weapon release strategies at strategic defense command centers.

DESCRIPTION: One of the Strategic Defense Initiative Organization's major human-in-control concerns is the optimum mix of human and machine decision making. Decision aids are needed which can provide the commander with the projected effectiveness of his weapon systems in terms of weapons used, reentry vehicles destroyed and assets saved under various release strategies. ESC has developed a fixed-algorithm prototype decision aid simulation based on stored scenarios and weapon release strategies. What is needed is application of this concept to the real world where a learning system can employ artificial intelligence to analyze the attack in progress and provide the commander with the effectiveness of each of the available weapon release strategies.

Phase I: Design a decision aid system and perform a feasibility analysis of its performance in supporting command centers.

Phase II: Develop and demonstrate a prototype decision aid system.

AF93-042TITLE: Element Failures in Adaptive Antenna ArraysAF93-042TITLE: Element Failures in Adaptive Antenna Arrays

CATEGORY: Basic Research

OBJECTIVE: Develop and evaluate a system to automatically detect and locate antenna array element failures and to automatically compensate for failures.

DESCRIPTION: Future radar systems will employ advanced array beamforming techniques to meet stringent operational performance requirements. To insure a state of readiness commensurate with achieving a high probability of mission success, array beam-forming capabilities must include provisions to detect, locate, and correct in real time for the effects of a variety of element failure types. Failures can result during operation from solid state component burnout, battle damage, and EMI or EW induced malfunction in the beamformer control subsystem. Such failures can

be partial or total, intermittent or permanent. Near-field techniques developed by Newelland and others are not necessarily appropriate for real time monitoring of array health during normal radar operation. Innovative techniques are needed to detect and correct for element failures such as frozen phase shifters, loss of amplitude and position distortion.

Phase I: A Phase I contract will involve analysis of the distinct array characteristics resulting from different types of element failures. Techniques which can uniquely identify failures in arrays having a modest number of elements (10-400) will be developed. Algorithms are to be formulated to compensate in real time for detected errors in order to restore main beam gain, pointing accuracy, low sidelobe level (40 to 60 dB), and antijam performance.

Phase II: For Phase II, a feasibility system will be designed and implemented to demonstrate the element failure compensation concept with an existing radar antenna array.

AF93-043TITLE: Thin Film Real-Time Holographic Materials and DevicesAF93-043TITLE: Thin Film Real-Time Holographic Materials and Devices

CATEGORY: Basic Research

OBJECTIVE: To develop the growth technology for implementing thin film real-time holographic materials for use in both surface incident (transmission and reflection) and guided wave holograms. The growth process must have potential for monolithic or hybrid-processing compatibility with OEIC device technology.

DESCRIPTION: Develop growth techniques for producing real-time holographic layers which operate at visible to near IR wavelengths and extend state-of-the-art fast response times and high diffraction efficiencies at low optical powers. These high optical quality thin film layers should be capable of integrating in guided wave devices with electro-optical modulators in a material system which is compatible with monolithic/hybrid fabrication of semiconductor electronics and laser diode sources. This program will provide the following: 1) optical quality real-time holographic thin film layers on passive and transparent optically flat substrates (capable of optically recording thick phase transmission and reflection holograms): 2) similar materials for in-plane control and out-of-plane coupling of guided waves for discrete device systems; 3) growth or fabrication compatibility with thin film electro-optical materials for discrete device systems; and 4) both real-time (with variable response time) and permanent (or fixed) holographic element materials technology compatible with monolithic/hybrid OEIC devices. holographic, and electronic characterization is required.

Phase I: Basic optical, holographic, and electronic characterization is required. In-house growth (or direct processing control) of the thin layers is required. Two each best effort optical quality grown samples of both thin film (about 10 to 100 microns thick and 1 centimeter diameter) 1) real-time holographic material and 2) electro-optical material (or holographic material grown on an integrated optics substrate) will be delivered in Phase I.

Phase II: The Phase II growth technology will include response time control and diffraction efficiency control for in-plane and out-of-plane coupling (eg. longitudinal and transverse electro-optical coefficients). This would include the ability to write permanent (or fixed) gratings. In addition, Phase II growth technology will optimize holographic thin films for use with laser diode wavelengths in the red to near IR.

AF93-044TITLE: Reduction of Environmental Hazards Due to Arsine Gas and DerivativesAF93-044TITLE: Reduction of Environmental Hazards Due to Arsine Gas and Derivatives

CATEGORY: Basic Research

OBJECTIVE: To develop and perfect methods to detoxify arsine gas and its derivatives.

DESCRIPTION: Arsine gas is used extensively in the preparation of many opto-electronic devices and high speed transistors. These devices are of extreme importance in the communication areas and in optical computers. Arsine is a colorless, non-irritating and extremely poisonous gas. The American Conference of Governmental Industrial

Hygienists has set 50 parts/billion as the maximum safe concentration for prolonged arsine exposure. Investigations of arsine technology and toxicity have indicated the following: 1. Epidemio-logical research has shown that 25% of the cases of arsine poisoning are fatal; 2. Toxicology investigations indicated death results from nephrotoxicity (kidney failure); and 3. Methods and techniques to detoxify the arsine that escapes the processing methods are severely needed. Information on the methods in practice today is seriously lacking. This investigation is primarily concerned with the research and development of techniques to detoxify arsine gas and derivatives thereof.

Phase I: Phase I will survey the current and possible methods of detoxifying the arsine gases. This will include an investigation of the chemistry of detoxification. The research will attempt to answer the following questions: 1. How can activated charcoal be treated to increase its chemisorption properties for arsine gas? 2. What other absorbing materials can be used for arsine (e.g. molecular sieves, glasses, etc.)? 3. How will the absorbed gases be removed and detoxified?

Phase II: An experimental program will be undertaken in Phase II in order to develop methods of detoxifying arsine gas and its derivatives. These methods should approach 100% efficiency. These methods are necessary for the future of the semiconductor industries.

AF93-045TITLE: Automated Documentation GenerationAF93-045TITLE: Automated Documentation Generation

CATEGORY: Basic Research

OBJECTIVE: Automated generation of software system documentation from knowledge base representations.

DESCRIPTION: Emerging software engineering technologies enable software systems to be developed using graphical or symbolic representations to formulate system requirements, specifications and implementations. Software documentation however must still be prepared using conventional manual methods. This leads to the all too frequent problem associated with software systems that the documentation does not accurately reflect the actual system design and implementation. There are two fundamental issues which are overcome by the automated generation of software documentation. First, using manual methods, it is impossible to insure that documentation accurately reflects the software system. Second, without automated coordination of software and documentation it is practically impossible to insure consistency. Advances in text generation technology when combined with the capabilities provided with the new generation of intelligent software engineering tools, make it feasible to automate the generation of software documentation from internal representations. The technical challenges of this effort will be to develop a general documentation generation framework that may be adapted to multiple input representations and output documents so that the product will be useful.

Phase I: Phase I shall investigate high payoff areas of application where significant gains in efficiency in acquisition and support of software systems may be achieved. A generation framework design which focuses on these high payoff areas will be produced and documented in a Final Technical Report.

Phase II: Phase II shall develop and demonstrate a prototype document generation framework for an integrated software engineering environment which encompasses the entire system life cycle and is capable of producing multiple types of documents.

AF93-046TITLE: 60 GHz Coaxial ComponentsAF93-046TITLE: 60 GHz Coaxial Components

CATEGORY: Basic Research

OBJECTIVE: Utilize l.85mm connectors to implement 60 Ghz coaxial isolators, noise sources, mixers, and other components.

DESCRIPTION: The 1.85mm connector has advanced coaxial technology through 60 GHz. However, there is a severe lack of available components which utilize this relatively new connector. This means that waveguide must continue to be used. Waveguide is more expensive, larger in size and heavier. In addition, it is not a baseband

technology. That is, it has a cutoff frequency below which it does not transmit.

Phase I: A particular component such as an isolator, noise source, mixer, directional coupler, or switch should be proposed for feasibility demonstration as the end product for Phase I. A major technical challenge requiring innovative ideas and approaches will be to achieve maximum performance and bandwidth. For those components where DC to 62 GHz operation cannot be achieved, 60 GHz is the desired center frequency. A low VSWR at a11 frequencies (including those out of band) is a major technical challenge.

Phase II: Phase II could take this initial component to prototype stage as well as demonstrate feasibility of other components. In addition, Phase II might also begin work with the 1.0mm connector which offers 110 GHz operation.

AF93-047TITLE: Ultra-Interactive Surface Process System for Combined Millimeter-Wave/Photonic Component FabricationAF93-047TITLE: Ultra-Interactive Surface Process System for Combined Millimeter-Wave/Photonic Component Fabrication

CATEGORY: Basic Research

OBJECTIVE: Demonstrate an interactive ultra-high vacuum wafer-level processing system with in-situ analytical capability for fabrication of surface-sensitive integrated heteroepitaxial photonic components and optical circuits.

DESCRIPTION: Although significant advances have been made for photonic devices at the discrete component level, integration of these same components in a circuit results in a performance decrease due to process incompatibilities. This increasing demand for integrating photonic components necessitates the development of an advanced processing system that can accommodate, in-situ, the wide variation in processing technologies required to fully realize analysis and fabrication of complex photonic epitaxial structures materials, devices and circuits. Modern USAF system requirements are increasingly met only by synergetically combined photonic and millimeter wave subsystems and components. Currently only the III-V semiconductors combine the electrical optical properties to fabricate such devices and circuits on a common substrate. The inability to evaluate surface physics during such processing steps as ion-based oxide removal, monolayer surface stabilization, dielectric passivation, and metallization limits current OEIC technology. The performance of these ultra-high performance opto-electronic circuits depends crucially on the chemical and electrical characteristics of the material surfaces and interfaces between atomic layers. In turn, these characteristics must be determined during the actual device fabrication for optimal performance.

Phase I: Phase I of this program would include the design of an ultra-high vacuum process module with the appropriate functional, in-situ surface monitoring subsystems and the ability to combine this analysis, in the chamber, with elemental III-V materials fabrication techniques. Such an interactive system would greatly augment the current state-of-the-art.

Phase II: Phase II will implement the Phase I design of the system, implement the Phase I design of the system, demonstrate its capabilities and deliver a functional System to RL/ERO for final test and analysis.

AF93-048TITLE: Database Schema TranslatorAF93-048TITLE: Database Schema Translator

CATEGORY: Basic Research

OBJECTIVE: Develop mathematical techniques to translate from one data model to another while preserving semantic context.

DESCRIPTION: Data models, (i,e. hierarchical, network, relational, etc.) have been developed to represent information. The structure of a data model provides additional information about the data, i.e. a semantic context. It is often necessary, due to changing requirements, information sharing needs, or performance considerations to replicate information from one database to another. This requires a schema translation capability that preserves the semantic context of the data as well as the data. Traditional approaches to schema translation require the development of specialized application software that is brittle and inflexible. Preservation of semantic context is left to the

programmer's implementation skills. More approaches map data models to a "canonical" representation which is reverse mapped to the target data model. Both approaches are inadequate. Semantic context is often lost on completion of the translation process, and the application software developed is extremely expensive and difficult to maintain.

Phase I: Phase I will identify approaches to direct schema to schema translation.

Phase II: Phase II will result in a prototype that can be evaluated in an operational context (such as DIA's Distributed Production Program).

AF93-049TITLE: Three Dimensional Optical Data Storage MediaAF93-049TITLE: Three Dimensional Optical Data Storage Media

CATEGORY: Basic Research

OBJECTIVE: Develop optical memory media which may be employed in a practical memory architecture.

DESCRIPTION: Three dimensional optical data storage devices have not made their way from the laboratory to practical use due to a lack of media which meets all of the necessary requirements for data storage. In the future it will be necessary to have optical memories for electronic computers which can store huge amounts of data (at least 10**12 Bits), at Terrabit data rates and persist for long periods of time at useful temperatures. Media technologies which may be suitable for this application include but are certainly not limited to: bacteriarhodopsin, spiropirobenzan, electron trapping, photon echo, photorefractives and dye polymers.

Phase I: Phase I should identify candidate media and characterize the optical properties with respect to writing energy, recording time, dynamic range, storage density, and crosstalk.

Phase II: Phase II will incorporate this media into an usable architecture.

AF93-050TITLE: Self-Routing Optical Interconnect Digital Computer NetworksAF93-050TITLE: Self-Routing Optical Interconnect Digital Computer Networks

CATEGORY: Basic Research

OBJECTIVE: Develop innovative techniques to eliminate the need for external control in optical switching systems.

DESCRIPTION: Future Air Force digital signal processors will need optical interconnects to handle the large amounts of data generated in a multi-sensor tactical environment. To speed this data flow process within and between digital computers, computer switching systems which allow optically encoded data packets to perform self-switching functions are needed. This in-band type of switching offers greater speed and flexibility than out-of-band architectures which require additional communications channels to perform switching functions.

Phase I: During Phase I, innovative designs for self-switching networks will be developed. The most promising design will be demonstrated via a one-channel engineering development model.

Phase II: During Phase II, working in the Rome Laboratory Photonics Center, a more advanced network will be developed, integrated with a digital computer, and evaluated.

AF93-051TITLE: Waveform and Vector Exchange Specification (WAVES) and VHSIC Hardware Description Language (VHDL) Modeling GuidelinesAF93-051TITLE: Waveform and Vector Exchange Specification (WAVES) and VHSIC Hardware Description Language (VHDL) Modeling Guidelines

CATEGORY: Basic Research

OBJECTIVE: Develop guidelines for creating and using WAVES in a design and test environment.

DESCRIPTION: With the enhancements of Very High Speed Integrated Circuits (VHSIC) technology, DoD systems are emerging with increased performance, reliability and maintainability. As a result of increasing design complexity, the need for affordable and complete testing and life-cycle support is essential. The VHSIC and Advanced Tactical Fighter programs identified these requirements and supported the development of the VHSIC Hardware Description Language (VHDL), for capturing digital design information in a standard, machine-readable, non-proprietary format, and the Waveform and Vector Exchange Specification (WAVES), for describing stimulus and response information for testing electronic hardware. WAVES bridges the gap between design and test by providing the ability to simultaneously represent stimulus and response waveforms and vectors for both simulation and test purposes. Although WAVES and VHDL are accepted IEEE standards, and are the mechanisms to achieve concurrent development of design and test information for life-cycle support, guidelines and recommended practices regarding the use of WAVES and VHDL for electronic system development do not exist. In addition, adequate examples are not available to assist those required to deliver WAVES and VHDL descriptions, as specified in MIL-STD-454, Requirement 64.

Phase I: Phase I will assess state-of-the-art of VHDL hardware design, and document the recommended guidelines that apply to utilizing WAVES datasets for design verification.

Phase II: Phase II will use the recommended practices of Phase I to develop VHDL and WAVES examples which demonstrate the use of WAVES in a design and test environment. A guideline accompanying the examples will give step-by-step instructions on how to create and use WAVES for various design and test applications.

AF93-052TITLE: Reconfigurable Holographic FiltersAF93-052TITLE: Reconfigurable Holographic Filters

CATEGORY: Basic Research

OBJECTIVE: Demonstrate a rapid wavelength-configurable filter for optical surveillance sensors.

DESCRIPTION: Future optical sensors will require multi-band capability to accurately discriminate and identify targets. Current approaches to sensing different wavelengths include multiple aperture systems and sensor telescopes incorporating reflective/transmissive beamsplitters. In the first case, system size-weight-power-complexity increases to cover the wave bands of interest. In the second case throughput is irrevocably reduced by the absorptive and scattering losses that occur in sequential filter components. Holographic techniques hold promise for simplifying these operations, by incorporating in a single component rapidly selectable diffractive gratings for directing or filtering different wavelengths. Electrical or optical selection of different stored holograms could provide high resolution multi-spectral data for a wide variety of applications. Much information could thus be gained from a target over a matter of seconds, with a very compact lightweight sensor package.

Phase I: Select candidate materials with suitable transmissivity and holographic storage characteristics to meet reconfigurable filter requirements. Develop techniques for impressing, and switching holographic gratings several times a second, on the candidate materials. Design a multi-hologram component that can operate at several wavelengths applicable to surveillance.

Phase II: Design and build a laboratory breadboard for demonstrating the feasibility of using reconfigurable holograms as beamsplitter-type filters. Conduct performance evaluations of these components at visible, mid- and long-wave infrared wavebands. Develop conceptual sensor designs utilizing these holographic elements for terrestrial and space-based multi-spectral sensing applications.

AF93-053TITLE: Parallel Optical Memory InterconnectsAF93-053TITLE: Parallel Optical Memory Interconnects

CATEGORY: Basic Research

OBJECTIVE: Study the problem of the design and fabrication of optical memory interconnects for future signal processing interconnect applications.

DESCRIPTION: Possible optical memory architectures of the future necessitate the development of high bandwidth optical interconnect devices. Due to the necessity for high data rates, and memory requirements for computers in the future, optical 3PD memory technology has been identified as one possible solution to this problem. Some architectures for 3PD memory show great promise for on-line memory needs of the future. One problem with the implementation of such devices is in the area of device interconnections. At this time, no electronic or fiber optic bus meets the needs of these devices. Free space interconnects have great potential to correct this deficiency. The interconnects should be dynamically reconfigurable to connect various optical memories: RAM, cache and associative as well as with optical and electronic processing modules. The relative ease of maintenance and extremely high data rates make these interconnects attractive. The greatest difficulty in the implementation of these devices at this time is due to their vibrational sensitivity. For this reason, amplitude independent digital encoding techniques should be studied. Architecture considerations such as environmental isolation and throughput rate should be investigated as well.

Phase I: Phase I should at a minimum provide an analysis of these problems and a plan of action for the development of these devices.

Phase II: During Phase II further work in this area will at a minimum produce a demonstrable architecture.

AF93-054TITLE: Strained-Layer Quantum-Well Laser Structures for Microwave ApplicationsAF93-054TITLE: Strained-Layer Quantum-Well Laser Structures for Microwave Applications

CATEGORY: Basic Research

OBJECTIVE: Develop high-gain semiconductor laser structures for direct modulation at microwave frequencies.

DESCRIPTION: The next generation of high speed analog optical links for microwave and millimeter wave transmission require new designs for semiconductor lasers. Laser bandwidths are presently limited by the relatively small differential gain coefficient of bulk material. Development of lasers with bandwidths beyond 25GHz requires a substantial increase in the differential gain coefficient which can be achieved by the incorporation of a structure with quantum confinement, modulation doping and strained quantum wells. These structures can be developed in GaAs or InP based material systems. QW lasers have also shown less spectral chirping, lower threshold current, narrower linewidth, lower noise and less temperature dependence than bulk lasers. Collaboration with a university or large company which has the facilities necessary to fabricate QW devices is encouraged.

Phase I: Phase I will determine the feasibility of developing microwave QW laser structures.

Phase II: Phase II would attempt to develop a quantum-well laser module with demonstrated bandwidth exceeding 20GHz.

AF93-055TITLE: Large Wafer MOCVD Production System ComponentsAF93-055TITLE: Large Wafer MOCVD Production System Components

CATEGORY: Basic Research

OBJECTIVE: Define and implement changes to current MOCVD systems that result in a high through put of large diameter wafers.

DESCRIPTION: There is currently an increasing DoD demand for the production of Gallium Arsenide and Indium Phosphide based devices for incorporation into DoD electronic and opto-electronic systems. For very high frequency devices, a low cost/high yield epitaxial growth technology capable of growing on large diameter wafers is required. Metal Organic Chemical Vapor Deposition (MOCVD) is one technique that is thought to be particularly suited for high throughput. However, at the present time there are no MOCVD production based systems that are capable of uniformly processing 4" and 6" wafers.

Phase I: The Phase I effort should be devoted to researching the process requirements for a 6" MOCVD single wafer system with emphasis on production. Areas to be addressed should include single wafer versus barrel reactors,

physical space requirements, effluent handling, etc.

Phase II: For Phase II, novel aspects of the findings found in Phase I should be demonstrated.

AF93-056TITLE: Pseudomorphic HEMT MMICs by Organometallic Vapor Phase EpitaxyAF93-056TITLE: Pseudomorphic HEMT MMICs by Organometallic Vapor Phase Epitaxy

CATEGORY: Basic Research

OBJECTIVE: Demonstrate the viability of pseudomorphic high electron mobility transistor (HEMT) fabrication for MMIC with metal-organic chemical vapor deposition manufacturing technology.

DESCRIPTION: Although pseudomorphic (PM) HEMT MMICs have demonstrated the best performance of a11 the device technologies at microwave and millimeter wave frequencies, truly manufacturable HEMT technologies have not yet been developed. As a result, low cost pseudomorphic HEMT circuits and MMICs are not commercially available. This may be in part due to PMHEMT device fabrication being singularly reliant on MBE technology which produces high purity material but is inherently not amenable to multi-wafer manufacturing. This in turn translates to high cost and increased manufacturing time for the MBE technique. In contrast OMCVD technology is capable batch processing but to date the material quality is lacking. In all, enhancing the material purity available from OMCVD could result in considerable overall cost savings for high speed compound semiconductor devices.

Phase I: Phase I of this program should therefore focus on the research of OMVPE or OMCVD of PMHEMT structures to determine suitability for MMIC fabrication.

Phase II: Phase II will demonstrate the growth of PMHEMT wafers with optimum device structures determined in Phase I. Also HEMT circuits such as power amplifiers will be fabricated and compared to MBE-fabricated circuits.

AF93-057TITLE: Superconductive Technology for Microwave/millimeter Wave Antenna SystemsAF93-057TITLE: Superconductive Technology for Microwave/millimeter Wave Antenna Systems

CATEGORY: Basic Research

OBJECTIVE: The development of superconductive components for monolithic antenna systems.

DESCRIPTION: Recent Accomplishments in low and high temperature superconductivity offer the possibility of significant new advances in monolithic antenna technology for microwave to the submillimeter wavelength regimes. Innovative research proposals for the application of superconductivity include but would not be limited to monolithic microwave, millimeter and submillimeter integrated array applications. Examples of components include oscillators, mixers, filters, isolators, circulators, and antenna feed structures. Electronically variable ways to control power, amplitude and phase or time delay of large wideband phased-arrays are of interest. Innovative wideband, monolithic, phased-array antenna elements are needed which are compatible with thin-film superconducting feeds, are efficient radiators and at the same time provide thermal isolation of the superconductive feed circuits from ambient free-space temperatures. Research to develop sub-systems such as monolithic integrated receivers and frequency synthesizers is required. A/D converters, shift registers and signal processing circuits operating in the giga- to multi-gigahertz regime are desired to advance the state-of-the-art of digital phased array antenna control.

Phase I: A Phase I contract will involve analysis of the theoretical background, and preliminary experiments and tests to clearly demonstrate the technical feasibility of the proposed development concept.

Phase II: A Phase II contract will require the development, test, analysis and conclusive proof of the concept.

AF93-058TITLE: Formal Verification of VHSIC Hardware Description Language (VHDL) ModelsAF93-058TITLE: Formal Verification of VHSIC Hardware Description Language (VHDL) Models

CATEGORY: Basic Research

OBJECTIVE: Develop analysis techniques to utilize existing Formal Verification tools to verify digital hardware designs written in the VHSIC Hardware Description Language (VHDL) .

DESCRIPTION: The driving force for requiring VHDL within the DoD is to reduce the escalating Life Cycle cost associated with device development, testing, maintenance, and re-procurement. To achieve this goal, the DoD now requires that all electronic devices delivered be documented in VHDL. VHDL designs capture the behavior and structure of an electronic system, subsystem, or device, in a machine processable, simulatable, and hierarchical format to be used in all phases of development. However, determining the correctness of a design by exhaustive simulation is not a feasible methodology due to the cost and time required to generate the test and simulate the model. In contrast to simulation, formal verification of hardware is a mathematical proof that the design of a digital circuit satisfies certain properties for every input. Formal verification tools can be used to prove that hardware designs satisfy properties such as functional correctness, safety, security and timing.

Phase I: Phase I will demonstrate the technical feasibility of this effort by selecting a formal verification tool and applying it to a VHDL model of appropriate difficulty.

Phase II: Phase II will identify any barriers between VHDL and the formal verification tool selected and make enhancements to overcome these barriers.

AF93-059TITLE: Real-Time High Performance Software Visualization ToolAF93-059TITLE: Real-Time High Performance Software Visualization Tool

CATEGORY: Basic Research

OBJECTIVE: Develop a software tool to graphically depict the timing of real-time software.

DESCRIPTION: During development of real-time software, the engineer must be sure the software has completed its function before some time period has expired. This time period is called a time constraint on the software, and the time limit is the deadline. These deadlines are of two types, a hard deadline that must be met on every execution of the software, and a soft deadline is one that can be surpassed once in awhile without critical error. Therefore, while developing software for real-time systems the engineer has two major problems to keep in mind, first does the software perform its function before the deadline. Second, will the software meet its deadline if it is ported to another target architecture. In order to determine if a software system has met its real-time deadlines, a more intuitive approach would be to actually see different processes meeting or exceeding their deadlines. This visual depiction makes the information about the processes more comprehensible and easier to understand.

Phase I: Phase I of the effort will concentrate on how the software timings can be depicted in a comprehensible manner, and how such timings can be collected.

Phase II: Phase II will focus on implementing the findings of Phase I in a preliminary tool, and targeting this tool to parallel machines.

AF93-060TITLE: Software Reliability Assessment for Distributed SystemsAF93-060TITLE: Software Reliability Assessment for Distributed Systems

CATEGORY: Basic Research

OBJECTIVE: Develop software reliability assessment models for distributed architectures.

DESCRIPTION: With the growth of distributed computing in real time DoD applications, a more sophisticated approach for software reliability assessment which accounts for the effects of replication, concurrency, data dependencies, fault containment (and propagation), fault tolerance, incorporation of commercially available

components, components taken from reusable software libraries, and other properties is required. The outcome of this research will be a framework and one or more software tools for developing a composite system-level reliability and availability assessments for a distributed system together with a means of accounting for the effects the expected types of failures.

Phase I: In Phase I, a model framework and a means of adapting one or more established software reliability models to a distributed software system will be developed.

Phase II: In Phase II, the model will be extended to account for other aspects of distributed systems (those noted in the second sentence) and validated using failure data from large real time distributed systems.

AF93-061TITLE: Ultra-Low-Power Semiconductors for Multi-Chip ModulesAF93-061TITLE: Ultra-Low-Power Semiconductors for Multi-Chip Modules

CATEGORY: Basic Research

OBJECTIVE: Demonstrate Low-power Semiconductor innovations for use in advanced packaging technologies (e.g., Wafer Scale Integration, Multi-Chip modules, etc.).

DESCRIPTION: These breakthroughs will be required to construct highly dense electronic systems with a power density compatible with state-of-the-art thermal management approaches. The trend in electronics at the component and system level is for ever increasing density. As electronics devices get smaller, they consume less power, but since they are smaller, more of them can fit into a unit area, and hence the power consumed by an integrated circuit does not necessarily decrease with time. With the advent of two-dimensional multi-chip modules (MCMs), and the increasing interest in three-dimensional MCMs, the power density of a system in area and volume is expected to grow quite dramatically. Of course, the heat density goes up approximately at the same rate the power density goes up, so thermal management becomes an inhibiting factor. Two solutions include (1) the introduction of various apparatus to improve the heat removal ability of as-built electronics and (2) lowering the power of the electronics components. While much attention is beginning to be placed in the first approach, relatively little attention has been placed toward the reduction of power in electronics components themselves, other than that which comes about naturally through feature size reduction. We seek more innovative solutions that go beyond, and most eagerly sought after are those solutions which minimize impacts to existing semiconductor fabrication processes. If one could build logic devices, for instance, in an existing process that consumed five to ten times less power, then the dissipated heat generated would be reduced by a similar factor. On a system level, where millions of such devices would be employed the savings translates into improved size and weight and therefore cost due to the reduction of power and heat. In some cases, these ultra-low power devices would enable systems to be built that were previously inconceivable due simply to the inability to place all of the components within proximity due to the heat dissipation problem.

Phase I: A successful Phase I proposal will address the aforementioned concerns in the form of analysis, design, and tests to the maximum degree possible. The groundwork for lower power devices that achieve approximate density parity to devices built in the current state-of-the-art must be clearly established.

Phase II: In Phase II, we will request that a demonstration system be constructed to prove that ultra-low power device technology is possible. This Phase II system will be compared against a conventional version of the same system to fully quantify the advantages of the proposed approach.

AF93-062TITLE: High Input/Output Pin Count Advanced Electronic PackageAF93-062TITLE: High Input/Output Pin Count Advanced Electronic Package

CATEGORY: Basic Research

OBJECTIVE: Develop survivable, high input/output bandwidth packages for simple and compound multi-chip modules and wafer scale integrated circuits.

DESCRIPTION: These multi-chip modules and integrated circuits must meet the high performance and reliability requirements of future military systems. The number of signals and power conductors required to service single and multi-chip packages has grown steadily since the inception of the integrated circuit itself. Contemporary solutions for military electronics are limited to those which provide a hermetic barrier separated the components from the environment. The associated packaging approaches, which are usually based on peripherally distributed pins or pin grid arrays, are inadequate in addressing the growth expected in pin count over the next five to seven years. Even pin grid arrays, which are currently used to achieve pin counts of nearly 400, create more problems than they solve at pin counts much higher than this. As such, superior packaging approaches are required, ones that provide the ability to hermetically enclose electronics and still provide large numbers of high-performance signal (to 3000 Mhz and beyond) and power interconnections between the enclosed components and the next higher level of packaging. At the same time, to preserve the density advantage of two- and three-dimensional multi-chip modules, this superior package must support highly efficient thermal transfer and "tile packaging" (the ability to arrange packages in avery spatially efficient manner onto a planar wiring board). Needless to say, these packages must endure ground, air, and space environments, and perform reliably in mechanically and thermally rugged environments. The package should in no way compromise the radiation survivability of the components enclosed. And, believe it or not, this package should also be economically effacious, as much as one would expect based on the cost trends of packaging since the 1970s.

Phase I: Clearly address the aforementioned issues through a superior package design with as much groundwork in analysis and test as possible. Leveraging into the infrastructure is important, and as such the package features (size, for example) should comply, where reasonable, to existing and emerging government and industry standards.

Phase II: The Phase II program will construct and comprehensively test prototype packages that are expected to closely resemble (if not coincide with final products). The packages shall be evaluated with thermal simulation substrates (package mockups with distributed heat elements) for thermal performance. They also shall be evaluated in various test conditions (e.g., highly accelerated stress tests and conventional MIL-STD-883 "shake, rattle, and roll" tests) for physical and electrical interconnect integrity (from dc to 800 MHZ pulsed digital waveforms). The conclusion of Phase II would provide many interface opportunities with various military and space projects that will require superior package solutions.

AF93-063TITLE: Integrated Circuits & Multi-Chip Modules: Space Qualified, Radiation Hardened Optoelectronics InterconnectAF93-063TITLE: Integrated Circuits & Multi-Chip Modules: Space Qualified, Radiation Hardened Optoelectronics Interconnect

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate a highly compact, space qualified, radiation hardened optoelectronic interconnection capability for use with multi-chip modules.

DESCRIPTION: These multi-chip modules and integrated circuits are intended for use in analog and digital high-performance electronic systems. Since the first integrated circuit, the signal bandwidth requirements of integrated circuits have climbed steadily from 14-16 signals to over 400 signals. Based on this trend, some have estimated that as many as 10, 000 high speed signals will be typical in systems by the year 2000. The advent of multi-chip modules has done nothing but exacerbate this problem since they contain up to several dozen complex integrated circuits. Clearly, new solutions will be required to handle the interconnection bottleneck that may occur if only wire-based solutions, which have a very limited expansion capability, are pursued. Optical interconnections between multi-chip modules (MCMs) will provide greatly improved interconnection capability and therefore higher performance for future space systems.

Phase I: A prospective Phase I effort will assess current trends in electronic packaging, including two- and three-dimensional MCM and WSI technologies and will demonstrate optoelectronic concepts that can be physically scaled for inter-MCM signal interconnections. Innovative solutions are sought not just for digital MCMs, but for analog and mixed-signal applications.

Phase II: The Phase II effort will demonstrate the practical application of a compact, survivable, and reliable compound MCM system that demonstrates the enabling benefits of optoelectronic interconnections. A successful

Phase II effort would pave the way for transition to candidate user applications.

AF93-064TITLE: Electrode/Electrolyte Interfaces in Solid State Polymer Electrolyte CellsAF93-064TITLE: Electrode/Electrolyte Interfaces in Solid State Polymer Electrolyte Cells

CATEGORY: Basic Research

OBJECTIVE: Investigate electrode/electrolyte interfaces in solid state battery cells and develop methods to reduce degradation of the interface region.

DESCRIPTION: There is a need within the Air Force to develop secondary batteries with high energy density and long cycle life for use on military satellites. Doing so will decrease the weight of satellites, thus saving on launch costs, while increasing overall satellite lifetimes. Solid state polymer electrolyte batteries have the potential to offer energy densities that are 4-5 times greater than current batteries. However, solid state batteries currently suffer from a number of problems that limit their life cycle capabilities. One of these problems is the degradation of the interface region between the electrodes and the electrolyte leading to premature cell failure. It is proposed that a program be undertaken to address the basic issues and processes at work in the electrode/electrolyte interface and develop an approach for improving the stability of this region.

Phase I: Phase I should concentrate on identifying the processes at work in the interface region and how they impact the overall integrity of the region. A methodology for solving these problems should also be formulated.

Phase II: Phase II will concentrate on applying the methodology/processes identified in Phase I and the fabrication and testing of benchtop cells utilizing these processes.

AF93-065TITLE: Advanced Cryocooler ComponentsAF93-065TITLE: Advanced Cryocooler Components

CATEGORY: Basic Research

OBJECTIVE: Develop advanced technology components generic to current cryogenic refrigeration systems.

DESCRIPTION: These new components shall be utilized to improve performance, life, reliability, producibility, and/or cost effectiveness of cryogenic refrigeration systems for spacecraft applications. Current technology is based on cryogenic refrigerators such as linear Stirling cycle, linear drive Pulse Tube, rotary turbo-dynamic reverse Brayton cycle, thermo-chemical and thermo-physical sorption compression Joule-Thomson cycle, and linear drive mechanical compression Joule-Thomson. Analysis of these various cycles discloses that there are generic sets of component technology common to several of these devices. Rather than concentrate on a singular refrigerator design and development, the intent of this project is to promote the development of advanced technology generic components. Given the improved components, improved total system can be subsequently integrated and demonstrated.

Phase I: During Phase I, the design process applicable to the specific component proposed for investigation will be prepared and typical implementations analyzed.

Phase II: During Phase II, representative samples will be fabricated, fully characterized, and subjected to demonstration testing. Examples include; linear flexure bearings, linear motors, position sensors, non-contacting reciprocating sleeve and position assemblies, and servo controlled electronic power supplies are all used in linear drive Stirling cycle, Pulse Tube, and Joule-Thomson cryogenic refrigerators. Check valves are common to all Joule-Thomson devices. Regenerators are common to Stirling and Pulse Tube machines. Recuperators are common to reverse Brayton and Joule-Thomson machines. Turbine and compressor assemblies of the reverse Brayton cycle machine exhibit common technology in the wheel and nozzle designs, the bearing assemblies, and the motors and alternators. Cryogenic triple point phase change periodic heat sinks (at 120 K and 140 K) and cryogenic thermal switches are examples of system components which can be applied to most cryogenic refrigeration systems regardless of the specific cycleutilized.

AF93-066TITLE: Passive Sensor System Payload Models and SimulationAF93-066TITLE: Passive Sensor System Payload Models and Simulation

CATEGORY: Basic Research

OBJECTIVE: Develop models and simulations of space based electro-optical sensor payload millimeter/microwave passive sensor payload, and spacecraft bus vehicle.

DESCRIPTION: These simulations will be separately developed and later integrated into a multi-payload system simulation. The passive sensor simulation and host vehicle simulations will include all subsystems needed for the simulations of passive sensors suites and the host vehicle. The simulation will be used to identify critical path technologies by providing a framework for evaluating various system alternatives and to allow hardware to be incorporated into the simulations to evaluate actual subsystem performance. The contractor shall design the model of the space based electro-optical surveillance payload, millimeter/microwave passive sensor payload, and the host spacecraft bus vehicle and identify quantitative measures of effectiveness that may be used to evaluate performances of the passive sensor payloads and bus vehicle simulation. These models and the effectiveness analysis tools will be used to identify the subsystems to be simulated and to develop general purpose interface specifications for the payload systems and associated subsystems and spacecraft host bus simulation. The interface specifications and subsystem models will be suitable for rule-based, hybrid (combinations of rule-based/waveform), comprehensive emulations. A critical feature of the models, simulations, and interface will be the ability to incorporate hardware and operational data into the simulations. The contractor shall provide recommendations of computer equipment to host the simulations, required training and minimum staff necessary to operate and maintain the simulations. The effort will incorporate government owned subsystem simulations and performance data where appropriate and available.

Phase I: Deliverables shall include a system design for the model, interface specifications for the model, and recommendations for computer equipment software, training and staff needed to operate and maintain the simulations.

Phase II: This phase will be to code the simulation of the space based passive sensor subsystems, host vehicle, and effectiveness analysis tools. The simulations will be rule-based (simple relationships to describe system and subsystem performance) models. Incorporation of government owned simulations in encouraged. Suitability of the simulation, interface specifications, and suitability of the analysis tools will be emphasized.

Phase III: This phase will refine the rule-based passive sensor simulations and host vehicle into comprehensive emulations and incorporation of hardware and operational data info the subsystem simulations. A key objective of this phase will be the success and suitability of integrating the passive sensor simulations, host vehicle simulation, and government owned simulations into unified system simulation. Suitability of the simulation, integration, interface specifications, simulation runtime, computer equipment performance, operation and user interface, and effectiveness of the analysis system will be emphasized.

AF93-067TITLE: Radiation-Hardened Silicon Charge-Coupled Device or Alternate Visible Detector AF93-067TITLE: Radiation-Hardened Silicon Charge-Coupled Device or Alternate Visible Detector

CATEGORY: Basic Research

OBJECTIVE: Develop silicon charge-coupled devices or alternate visible detectors that are hard to proton and other radiation.

DESCRIPTION: Charge-coupled devices are very useful for space-based space surveillance and a variety of imaging applications due to their high sensitivity, low noise and high operating temperature. The most critical technological issue in the use of silicon charge-coupled devices is their vulnerability to nuclear radiation. Even a few kilorads of low-energy protons can cause serious degradation in the charge transfer efficiency, and also increase the dark current of the charge-coupled devices, and thus reduce their surveillance and imaging capabilities. The total doses needed to cause the above damage are easily accumulated in the course of a few months in the space environments encountered in mission orbits passing through the Van Allen belts. In order to improve the radiation hardness of the silicon

charge-coupled devices or alternate visible detectors, it is essential to develop a detailed understanding of the damage process. The damage should be experimentally studied as a function of proton and other radiation energy, flux density, temperature, and pixel size. Theoretical analysis should be made with the help of computer codes such as Transport of Radiation in Matter. From these, a detailed understanding of the proton and other radiation induced damage in silicon charge-coupled devices or alternate visible detectors should be developed and recommendations made to increase the hardness.

Phase II: In Phase II, prototype silicon charge-coupled devices or alternate visible detectors, with increased hardness, should be developed based on the findings of Phase I.

AF93-068TITLE: Carbon-Carbon Joining Technology for Space StructuresAF93-068TITLE: Carbon-Carbon Joining Technology for Space Structures

CATEGORY: Basic Research

OBJECTIVE: Develop methods and techniques required for joining Carbon-Carbon Space Structures using elevated temperature brazing technology.

DESCRIPTION: Carbon-carbon composite components, like other structural members, much be joined to create useful space structures. The manner in which these processes of joining and assembly are performed is generally the determining factor in the structural efficiency and suitability of the overall component. Critical deficiencies in available techniques for joining of carbon-carbon composite components severely limit their application to space structures. Development of braced carbon-carbon joining technology will offer the following immediate benefits: (1) reduced weight/mass/volume of joined carbon-carbon structures (parts such as bolts, nuts, and other fasteners can be eliminated), (2) elimination of the stress concentration problems associated with the holes required for mechanical joining schemes, (3) fabrication of tough high-strength joints, (4) ability to join carbon-carbon without degrading the oxidation protection coating, (5) resistance to thermal shock and thermal fatigue failure modes, (6) ability to form gas-tight joints, and (7) ability to join carbon-carbon to other materials, including metals, ceramics and composites. Novel techniques are needed to enable joining of carbon-carbon composites for application to space structures.

AF93-069TITLE: Autonomous Neural Control of Space PlatformsAF93-069TITLE: Autonomous Neural Control of Space Platforms

CATEGORY: Basic Research

OBJECTIVE: Apply neural network technology to the system identification and structural control of autonomous space platforms.

DESCRIPTION: The benefits of developing space platforms with decreased dependency on ground monitoring and support include reducing the need for ground communication and intervention, reducing the amount of required a priori knowledge of the behavior of the space structure by allowing on-orbit system identification and adaptive control of the structure, and on-orbit health monitoring and reconfigurability of sensors and actuators. Existing adaptations of neural networks to control systems have been characterized by ad hoc design approaches which have been highly dependent on the particular system to be controlled. An understanding of the dynamic of neural networks has also been limited.

Phase I: This phase will consist of determining the network architectures and learning schemes which are most successful for system identification and structural control problems, developing systematic techniques for selection of neural controllers which are appropriate to the given system of interest, and designing a rule-based control architecture which incorporates task-specific neural networks into an overall control system framework. A preliminary demonstration of the feasibility of this technology would also be conducted in this phase.

Phase II: Would involve a refinement of the software implementation of these methodologies and a hardware demonstration of them on an existing precision space structure testbed.

AF93-070TITLE: Missile Payload Vibration IsolationAF93-070TITLE: Missile Payload Vibration Isolation

CATEGORY: Basic Research

OBJECTIVE: Develop active/passive isolation system to isolate a spacecraft from a launch vehicle to reduce spacecraft dynamic loads.

DESCRIPTION: The design of a spacecraft requires knowledge of structural loads generated almost entirely due to motions induced by, and dynamic interactions with, the launch vehicle. These loads are primarily inertial, highly transitory, and are functions of the spacecraft, the launch vehicle, and external forces. Consequently, the design process is highly interactive. Various design procedures have been implemented to limit repeated analysis of coupled dynamic loads during spacecraft design evolution. However, a comprehensive spacecraft isolator design procedure has not emerged despite extensive commercial development of isolator technology in recent years.

Phase I: Phase I of this effort will formalize, and provide supporting analysis for an innovative isolation system. A survey will be performed to demonstrate the innovative nature of all major components of the proposed system.

Phase II: Phase II will demonstrate system effectiveness for representative payload and launch vehicle configurations through critical component hardware testing coupled with additional analysis and simulation. Phase III will provide a commercial payload-launch vehicle isolator system for flight demonstration.

AF93-071TITLE: Intelligent Spacecraft ReprogrammabilityAF93-071TITLE: Intelligent Spacecraft Reprogrammability

CATEGORY: Basic Research

OBJECTIVE: Develop the capability to reprogram on orbit satellite expert systems with a minimum of uplinked code.

DESCRIPTION: Current satellite systems and associated software have limited flexibility to cope with onboard hardware failures and to utilize disparate sensor data to infer failure mechanisms. The ability to modify the onboard information base for expert systems is needed to enhance space systems autonomy and expand the flexibility provided by expert systems. Management of onboard resources is mission and mode dependent; e.g., satellite users may choose to accept a shortened useful lifetime in order to obtain maximum performance in a high level of conflict situation. Autonomous spacecraft must be able to adjust space system performance for various mission critical modes by managing available spare resources and expendable even in the presence of faults. The software supporting this capability must be reprogrammable from the ground in the event of depletion of expendable or subsystem failures to maximize mission performance within remaining resources. Techniques for reprogramming should address less than total update of rule bases or cases verification and validation of uplinked code, use of existing telemetry capabilities of the Air Force Satellite Control network, and operation of there programmable computer module within the 1750A architecture. A goal for reprogrammability is to minimize ground contact time.

Phase I: Phase I will research the modes and architectures by which to update onboard software to add anomaly derived information and to compensate for degradation in mission performance of the spacecraft.

Phase II: Demonstrate reprogramming capability based on the approach developed in Phase I. The reprogramming technique will be demonstrated on the ground using a workstation simulation of a 1750A spacecraft computer.

AF93-072TITLE: Diamond Coated Insulators for Plasma and Microwave DevicesAF93-072TITLE: Diamond Coated Insulators for Plasma and Microwave Devices

CATEGORY: Basic Research

OBJECTIVE: Measure the protective and insulating properties of diamond coatings on surfaces exposed to high temperature plasmas and electric fields.

DESCRIPTION: The recent availability of Chemical Vapor Deposited (CVD) diamond and diamondlike coating technology makes its use in many plasma and microwave devices economically feasible. Insulating surfaces in many such devices, such as current feed through insulators, dielectric wave guides, and microwave windows, are often exposed to ultraviolet, x-ray, or particle radiation, high electric fields, or contact with high temperature plasma. The resultant electrical breakdown, ionization, and erosion of the insulator surface often terminates proper current delivery, limits device lifetime, or introduces undesirable impurities into the system. A CVD polycrystalline diamond surface may, in such applications, be the ideal choice for such insulators. Diamond has the highest dissociation temperature of any material and the material that does ablate (carbon) has a low atomic number (Z), lessening the effects of impurity radiation energy losses for hot low Z plasmas. Diamondlike surfaces, though less refractive than true diamond coatings, may be applied over larger areas and to a wider variety of materials, such as plastic, so should be considered a viable alternative. Two devices used by Phillips Laboratory (PL) whose longevity may be increased by the technology are ignitron and spark gap switches. One experiment whose performance may be enhanced by a reduction in high Z impurities is PL's Working Fluid Experiment (WFX). Large plastic current feed through insulators, such as those used on PL's MARAUDER compact toroid acceleration experiment, could benefit from a diamondlike coating in terms of longevity and contaminant evolution.

Phase I: Phase I will involve the measurement of fundamental properties of diamond coated surfaces pertinent to the application. The maximum surface electric field prior to the breakdown of a coated cylindrical insulator sandwiched between electrodes when exposed to various levels of ultraviolet radiation and background gas pressure could be measured using techniques which have been applied to more conventional materials (for comparison). The effects of commonly used surface conditioning techniques such as high temperature baking and glow discharge etching on these properties could be determined. Surface erosion rates and properties such as ablation species and susceptibility to tracking could be studied by spectroscopy, microscopic examination, and weighing, for example.

Phase II: Phase II could involve the fielding of coated insulators in actual devices whose performance or longevity are known to be effected by insulator properties. Device candidates selected for testing will be based on which show the most promise for improvement, based on Phase I results. Phase III could involve the development of the manufacturing techniques for the economical application of the technology on a commercial scale.

AF93-073TITLE: Model-Based Object Identification & Multisensor Fusion of Images of Satellites AF93-073TITLE: Model-Based Object Identification & Multisensor Fusion of Images of Satellites

CATEGORY: Basic Research

OBJECTIVE: Develop model-based process for fusing radar, visible, and infrared wavelength signature data of satellites to support identification and assessment.

DESCRIPTION: Phase I effort will explore and plan the process for an interactive model-based graphical means of fusing or merging radar, visible, and infrared wavelength image data of a satellite to support identification and updating or construction of an "as-is on-orbit" computer model of the satellite being imaged. Currently, there is no such process that exploits multiple sensors and is coupled to an integrated satellite model construction algorithm. This proposed process is intended to provide synergistic information that will substantially help answer possible questions about the satellite such as geometric configuration, orientation, surface temperature, and material properties. The nucleus of this model-based fusion process would be an interactive computer algorithm that would take the latest available model of the satellite as input and construct an updated or more detailed model based on the multisensor data input. The model-based fusion process must be capable of handling an initial computer input model with some or no initial information. This study will focus on sensor data from ground site locations for the wide band radar (Inverse Synthetic Aperture Radar - ISAR), visible, and infrared wavelength sensors engaged with satellites in low earth orbits. The

satellite model construction algorithm shall be compatible with the International Graphics Exchange Standard (IGES).

Phase I: Phase I efforts will include exploring, planning, and designing the interactive model-based graphical process.

Phase II: Involves the actual implementation of the Phase I plans on a computer graphics workstation, application to simulated radar, visible, and infrared wavelength images of satellites viewed from ground sites, and the demonstration of the satellite model construction process on the workstation based only on input image data. Varying amounts of distortion shall be introduced into the image data to determine there obustness and range of applicability of the newly developed fusion process. Distortion due to such things as diffraction effects overlong ranges, atmospheric distortion, residual phase distortions of atmospheric compensation systems, sensor noise contributions, and background noise shall be considered and factored into the fusing of the simulated images. Phase III may provide follow-on system development and transition to the Air Force Space Command.

AF93-074TITLE: High Current Cathodes Without a A-K Gap ClosureAF93-074TITLE: High Current Cathodes Without a A-K Gap Closure

CATEGORY: Basic Research

OBJECTIVE: Develop a material to provide electron current densities less than 1000 A/sq. cm. at electric field stresses less than 70 KV/cm.

DESCRIPTION: Phase I, effort will be directed towards determining field stress applied to the cathode, current density of the electron beam, and the gap closure rate as a function of field stress. The cathode material must provide 2 to 5 kA of current in a 5 cm radius solid beam when a 150 to 200 Kv pulse is applied to a 4 cm anode-cathode gap. The pulse width must be greater than 1 microsecond and operate in poor vacuum (pressure greater than 1. E-5 Torr). These parameters are to be demonstrated for single pulse operation. Phase II, emphasis will be toward expanding the operating parameter range and determining the number of shots (lifetime) from a single cathode without any loss of performance. The expansion of the parameter space includes higher field stress (eg 500 Kv across 6 cm), higher current density as is required for an annular electron beam (e.g. of order 1kA/sq.cm.), with a minimum pulse width of 1 microsecond. The material must allow at least 10 repetitions of 100 pulses/sec in 10 seconds without significant degradation of the vacuum pressure (as is seen with velvet). Phase III will emphasize engineering modifications for improved lifetime and repetition rate performance. Additionally, the ease of manufacturing and variation in the diode geometry must be addressed for varied applications.

AF93-075TITLE: Improved Modeling of Bauschinger Effects in Plastic FlowAF93-075TITLE: Improved Modeling of Bauschinger Effects in Plastic Flow

CATEGORY: Basic Research

OBJECTIVE: Extend validity of the current material plastic model essential for hypervelocity impact and orbital debris collision predictions.

DESCRIPTION: Accurate modeling response of materials used in space structures to high impulsive loading is central to the survivability assessment of space assets to kinetic impact and orbital debris. The typical plastic material model commonly used in predictive structural models, such as that of Johnson and Cook (Ref 1), assumes isotropic hardening. That is, the yield stress in any direction is the same and increases the same amount in every direction due to plastic flow. The assumption of isotropic hardening for nonhomogeneous material is an over simplified assumption which clearly contradicts the Well-Known Bauschinger effect (Ref 2). It can be shown that, alternate tensions and compressions do not result in isotropic hardening. A tension results in the material being softer to a subsequent compression, not harder. In turn the material is softer to the following tension, not harder. The Bauschinger effect is quite relevant to assessment of response of materials to hypervelocity impact and orbital collision phenomena. In a

hypervelocity impact event, a shock wave first produces a compressive pulse in the target and impactor. The compressive wave changes to a tensile wave upon reflection from a free surface, and therefore, the conditions for the Bauschinger effect are fulfilled in impact problems. Most material response codes do not allow the Bauschinger effect. Research efforts in viscoplastic (Ref 3) flow models have explored the effect, but not systemically, and not for materials and parameter regimes of interest to impact problems. To realistically predict the response of materials used in space structures, it is imperative to develop a realistic and experimentally verifiable plastic flow model.

Phase I: Design and begin development of a code which models the Bauschinger Effect in plastic flow.

Phase II: Complete development and demonstrate the modeling code designed in Phase I.

AF93-076TITLE: Laser Modulated Fiber Optic LinkAF93-076TITLE: Laser Modulated Fiber Optic Link

CATEGORY: Basic Research

OBJECTIVE: Develop a laser modulated analog fiber optic instrumentation link for use in high int3nsity electromagnetic environments.

DESCRIPTION: Currently fiber optic links are used to transmit analog signals measured on cables and electronics within weapon systems when exposed to high intensity electromagnetic fields. These signals are transmitted to recording systems in well shielded enclosures located several hundred meters from the test object by means of wideband analog fiber optic links. These links are currently capable of operating over a frequency range from a hundred kilohertz up to one gigahertz with a signal to noise ratio or dynamic range of thirty to forty decibels. Related work in the telecommunications industry has developed laser pumped Erbium doped fiber optic repeater amplifiers for long haul fiber optic transmission lines. The purpose of the Phase I effort is to investigate and demonstrate in the laboratory the feasibility of using the repeater amplifier technology as a means to provide analog modulation of the fiber optic link from an external signal rather than the current method of injection into the fiber. The goal is to improve the performance both in frequency response as well as overall dynamic range. An alternate application would be amplification of the injected signal to produce a higher gain with reduced noise levels. The external modulating signal could consist of a single pulse or multiple pulses. The frequency range of interest is from approximately one megahertz to five gigahertz. The signal levels of interest are on the order of tens to hundreds of milliamperes or several volts. The dynamic range and fiber optic link length should be consistent with those described above.

Phase I: Phase I efforts include a laboratory feasibility demonstration of the laser modulated analog fiber optic instrumentation link.

Phase II: Phase II effort will provide for limited testing of a prototype system in an actual electromagnetic test of a weapons system. Phase III will provide a rugged system capable of transition to Air Force advanced electromagnetic threat test programs and hardness surveillance testing. Alternate applications for this technology will also be explored during this phase.

AF93-077TITLE: Combination Microwave Circuit Analysis and Coupling CodeAF93-077TITLE: Combination Microwave Circuit Analysis and Coupling Code

CATEGORY: Basic Research

OBJECTIVE: Develop computational software that calculates the RF energy which couples into an aerospace asset and the response of its electronics.

DESCRIPTION: The Phase I effort will be research of possible method of combining High Power Microwave (HPM) coupling and circuit analysis computer simulations and selecting at least one for further exploration and implementation. This method must demonstrate the ability to meet the USAF's need for a way to calculate time-dependent response of an aerospace asset's electronics when exposed to a fast rise-time pulse of radio-frequency (RF) energy from the outside. An asset's susceptibility to high power RF energy is determined by several factors: the nature of the incident energy (pulse length, total energy, pulse shape, etc.), the loss or gain of the energy as it leaks into the asset (due to physical coupling through slots and holes and the characteristics of antennas or other sensors that give

the energy a path in), the loss or gain of the energy as it couples onto circuit boards or cables inside the asset, and finally the response of circuits and individual devices to the energy as it finally reaches the electronics. These gains and losses can be summed up in a general transfer function that is dependent on the characteristics of the incident HPM. Currently the USAF does not have a way to simulate both this coupling and the response of the electronics at the same time. Much of an asset's susceptibility can be tied to the response of a few components that are connected to antennas directly or that are vitally important to its operation. While simulation cannot replace asset experimentation, it can reduce costs by predicting trends that can aid test planning and shorten experiments, and by simulating the application of expensive hardening techniques to judge their effectiveness without actually placing them on the asset.

Phase I: The Phase I effort will consist of researching possible methods and down selecting to the best approach in combining HPM coupling and circuit analysis computer simulations.

Phase II: Phase II will implement the demonstrated method into a usable code for the government. The code must be able to model different assets, including missiles, aircraft, sensor pods and external ordinance. Coupling paths should include antennas and other sensors as well as physical apertures like hatches, slots, and radomes. As part of this effort, comparison with simple experimental results is necessary to further validate the computer simulation technique. Phase III should be a transition of the methods and the code to the civilian sector, with the basic technique modified to work with many applications such as EMC/EMI analyses. Further development will be necessary to meet these other needs.

AF93-078TITLE: Automatic System for the Detection of Microwave Related Personnel HazardsAF93-078TITLE: Automatic System for the Detection of Microwave Related Personnel Hazards

CATEGORY: Basic Research

OBJECTIVE: Develop a self-contained, portable, compact device for use in monitoring and detecting the presence of potential electro magnetic radiation hazards.

DESCRIPTION: In recent years, there has been a substantial increase in the variety and output power of pulsed RF and microwave sources used for electronics effects testing, along with the increased tendency to utilize experimental sources as soon as they are developed. Research-type ultra-high power sources often exhibit unwanted levels of radiation both in inconvenient directions and from unexpected locations. Assessment of whether such radiation exists, and whether or not it is safe, can become a frustrating and time-consuming procedure, which, at present, must be customized to the type of RF source involved. An RF detection system which is capable of rapidly and accurately discriminating between safe and hazardous radiation exposure conditions over a broad frequency range, regardless of the nature of the source(s) involved, is required.

Phase I: Phase I work should identify specific innovative methods for the experimental detection and discrimination of RF/microwave hazards, and demonstrate the feasibility of developing a portable RF/microwave hazard detector.

Phase II: Phase II work should implement the concept developed in Phase I, and demonstrate the availability of the prototype device to detect and react to a variety of hazardous RF conditions.

AF93-079TITLE: High-Power Semiconductor Laser MOPA Configurations Operating at 2-5 Microns AF93-079TITLE: High-Power Semiconductor Laser MOPA Configurations Operating at 2-5 Microns

CATEGORY: Basic Research

OBJECTIVE: Develop diode laser source in a master oscillator/power amplifier (MOPA) configuration which operates in the 2-5 micron (mid-infrared) regime.

DESCRIPTION: Semiconductor laser diodes are currently being developed to operate in the mid-infrared (MIR) wavelength range from 2-5 microns. These lasers are made from the InGaAsSb, HgCdTe, and pb-salt material systems

and typically have double-heterostructure (DH) active regions. Because of the narrow band gaps and valence band structures of these materials, losses due to non-radiative processes, such as Auger recombination and free-carrier absorption, are high. Therefore, MIR semiconductor lasers currently have very limited power output. Once those problems have been addressed, the power will still be limited by gain stripe width and catastrophic facet damage. One solution to this problem is to use a low-power MIR laser as a master oscillatory, then amplify the output via a separate power amplifier. Broad-area semiconductor optical amplifiers have been successfully demonstrated in the GaAs/AlGaAs material system, where nearly diffraction limited outputs of 12 Watts were reported. Because of the absence of feed backing these devices, large areas of the amplification medium can be used to amplify the output of the master oscillator.

Phase I: This effort shall explore the implementation of a MOPA configuration in MIR materials. The investigation shall address both high power output and good beam quality, as well as identifying any limitations to these goals. Once a suitable material system and design are identified, all growth, fabrication and material processing requirements necessary to implement the MOPA device (including both the master oscillator (laser) and the power amplifier) shall be addressed. Any unique optics necessary to implement the design shall also be identified.

Phase II: Phase II shall implement the Phase I design and develop a MIR diode laser MOPA device. This development will include the growth or purchase of epitaxial material, processing, testing and characterizing the devices. The test results and the MOPA devices will be deliverable at the end of Phase II. The technology developed has direct impact on the critical Air Force problems of Strategic Relocatable Targets, Secure Optical Communications, and Optoelectronic Warfare. Other USAF and commercial applications of this technology include optical communications, heterodyne detection, and high-resolution molecular spectroscopy.

AF93-080TITLE: Low-Dimensional 2-5 Micron Semiconductor LasersAF93-080TITLE: Low-Dimensional 2-5 Micron Semiconductor Lasers

CATEGORY: Basic Research

OBJECTIVE: Design and model diode laser structures with quantum-well, quantum-wire, and quantum-box active regions operating at 2-5 microns.

DESCRIPTION: Semiconductor laser diodes are currently being developed to operate in the mid-infrared (MIR) wavelength range from 2-5 microns. These lasers are made from the InGaAsSb, HgCdTe, and Pb-salt material systems and typically have double-heterostructure (DH) active regions. Because of the narrow band gaps and valence band structures of these materials, losses due to non-radiative processes, such as Auger recombination and free-carrier absorption, are high. QW lasers have been demonstrated which have lower thresholds and higher operating temperatures than their DH counterparts, which is due in part to the reduced Auger rates in the QW compared to the bulk. The reduced Auger rate in QW's is related to several factors, such as: (1) the reduction of allowed intraband transitions which conserve energy and momentum, and (2) the narrowing of the spectral gain curve as a result of the step-like density of states (DOS), which reduces the number of carriers above the threshold energy for the process. In quantum wire (quantum-well wire, QWW) or a quantum box (QB), the energy- and momentum-conserving transitions will be limited further by the additional quantization in the additional dimensions. Also, the one-dimensional DOS of the QWW will also reduce the spectral gain curve further because of the high density (infinite in the ideal case) at the bound energy levels. Likewise, the QB DOS is singular at the bound levels, so the width of the gain curve is infinitesimal when broadening mechanisms are neglected. All these factors should resulting lower thresholds and higher operating temperatures in QWW and QBlasers due to lowered Auger recombination probabilities. The fabrication of QWW's and QB's is a problem that is currently being addressed in two general ways, namely lithography and controlled growth. The former is accomplished by either etching the structure to form small lateral dimensions, which results in surface problems that are difficult to deal with, or the lateral structure can be defined by selective intermixing of the QW's. In this technique, impurities or other defects are introduced to the QW's in regions outside the QWW/QB regions where they induce disordering of the QW's during an annealing step. In controlled growth, the QW material is grown on a patterned substrate which causes thickness variations in the lateral dimensions, or vicinal growth of the QW material is done on and off-axes substrate. These techniques have been studied using GaAs-based materials

with varying levels of success.

Phase I: Select a material system in which quantum structures can be fabricated, define a technique to realize quantization in the lateral dimensions, and model various laser diode structures using QW's, QWW's, and QB's in the active regions. The lasers shall be designed for room-temperature operation in the 2-5 micron range, and modeling of the device shall include the effects of QW's, QWW's, and QB's on the Auger recombination rates well as other parameters (such as other non-radiative effects, threshold current, output power, etc.). The emphasis in Phase I is on the theoretical modeling of QW, QWW and QB diode lasers in MIR materials.

Phase II: Apply the concepts and designs of Phase I to the QWW fabrication. The lateral quantization technique shall be supported by experimental verification. The models developed in Phase I shall be refined as experimental data is acquired from the fabricated QWW's and QB's. The actual computer model will be deliverable at the end of Phase II. The technology developed has direct impact on the critical USAF problems of Strategic Relocatable Targets, Secure Optical Communications, and Optoelectronic Warfare. Other USAF and commercial applications include optical communications, heterodyne detection, and high resolution spectroscopy.

AF93-081TITLE: Thick Aberrator Compensation in Postdetection Image CorrectionAF93-081TITLE: Thick Aberrator Compensation in Postdetection Image Correction

CATEGORY: Basic Research

OBJECTIVE: Develop method of imaging through thick turbulence using multiple reference beacons and post-detection processing.

DESCRIPTION: Initially, effort will be directed towards research on imaging through thick turbulence when measurements of the turbulence at different points in the aberrator are known. Space object identification from the ground, weapons systems which need to sight and discriminate targets along horizontal paths through the atmosphere, and airborne imaging platforms all require high resolution images through thick aberrators. In anticipation of the requirements of this new generation of smart weapons and imaging systems, this contract will investigate high performance methods of solving the turbulence degradation problem based on partial knowledge of the aberrating media. The research will concentrate on how well techniques for compensation will work, methods for placing references throughout the aberrator, and the performance dependence on the number and type of measurements. The basic method of post-detection correction will be the baseline for the work, with analysis and computer simulations as the method of demonstrating system performance.

Phase II: Proposed new beacon geometries and methods, radiometry, and noise characterization will be the principle focus of the system application portion of the work. Augmentation of the analyses from Phase I, with attention to questions which arose in Phase I, will the be first task. A laboratory or field experiment for the final concept will be designed and executed. It should demonstrate both concept feasibility and predicted performance in agreement with Phase I and Phase II analysis and simulations. Phase III may provide a prototype system transitioned to the Phillips Laboratory for airborne or weapons systems proof of concept.

AF93-082TITLE: Electrically Tuned Multi-Element Fabry-Perot Spectral FilterAF93-082TITLE: Electrically Tuned Multi-Element Fabry-Perot Spectral Filter

CATEGORY: Basic Research

OBJECTIVE: Develop a monolithic electronically tunable multi-element spectral filter for spectral imaging and automated target recognition (ATR) applications.

DESCRIPTION: Multispectral imaging applications require an imaging spectrometer. This can typically be accomplished using a scanning spectrometer in conjunction with a conventional imaging system. Instead a tunable Fabry-Perot filter may be placed in front of a detector array. This design can offer a compact non-inertial system

design. Single element liquid crystal Fabry-Perot filters have been produced for this task. We require a multi-element spectral filter for more sophisticated spectral imaging applications. Such a multi-element filter would afford parallel processing capabilities in image processing applications. This filter would afford parallel processing capabilities in image processing applications. This multi-element filter may be based on liquid crystal or semiconductor technologies. A liquid crystal or quantum-well based phase shifter can be sandwiched between two broadband highly-reflective coating stacks to construct this filter. A device which has an operational spectral bandwidth of at least 20% of its center frequency is required. The device should operate in the visible to near IR wavelengths. A Finesse of 50 is required to afford adequate spectral resolution. The optical thickness of the Fabry-Perot cavity should be no more than 20 waves at grand center in order to afford adequate rejection of other in-band frequencies. A throughput at line center of at least 30% is necessary for a successful candidate. The device should have an extinction ratio of over 100: 1. Actuation speeds of 20 Hz or more are desired.

Phase I: This phase will consist of the manufacture of a one-dimensional device consisting of at least 50 rectangular shaped elements. The aspect ratio of these elements shall be at least 100:1 (length to width). The total active area of the multi-element device should be approximately 1 in 2. A successful candidate will address the insertion loss, temporal and spectral bandwidth, Finesse, optical quality, and extinction-ratio issues. The device should operate between 0.5-1.5 microns wavelengths.

Phase II: Phase II will consist of extending this device technology for production of two-dimensional devices. These devices will consist of two dimensional arrays of individually programmable spectral filter pixels for the purpose of multi-spectral image processing.

AF93-083TITLE: Data Processing Routines for Adaptive Optics SystemsAF93-083TITLE: Data Processing Routines for Adaptive Optics Systems

CATEGORY: Basic Research

OBJECTIVE: Develop data processing system based on Fourier Transform theory for multiple input/output electrical and optical hardware measurement calculations.

DESCRIPTION: Adaptive optical systems being tested by the Phillips Laboratory are multiple input/multiple output (MIMO) control systems that can consist of over 100 channels of highly coupled controlled actuators and wavefront sensors. At the present time there is no available software to support processing the data from these MIMO hardware systems. Approaches such as Singular Value Analysis and Eigen value analysis are presently being developed by control theorists to evaluate MIMO system performance. Optical characterization techniques that use Zern like polynomial decompositions have been used for many years to characterize optical system performance. Fourier Transform techniques are widely used to evaluate single input/single output and multiple input/single output control systems. A logical and needed effort is to design and develop software that can process hardware data to evaluate MIMO system performance. One function of this software might be to decompose sets of measured data into singular value modes and then calculate magnitude and phase versus frequency functions for the modes based on the gathered test data. Another useful function of such a program might be a transformation between singular value modes and Zern like polynomials. This would permit comparing electrical errors measured with the control loop to optical errors measured with interferometer instruments. Other useful analyses functions would be Strehl ratio plot computed from control system errors, and rms phase error calculations. It would be beneficial if the software could run on a PC such as a 486.

Phase I: The software package architecture design would be the Phase I objective. The successful small business would need to understand both optical system characterizations and MIMO control systems, in order to plan & design the software package.

Phase II: Phase II would require the coding and demonstration of the software package. Initial demonstrations of the processing routines would be expected to be run by the contractor using data from adaptive optics simulations provided by the contractor. If the package was successful the Phillips Laboratory would provide measured data from adaptive optics hardware for the final level of package checkout. Phase III of the effort would be to develop a commercial package that could be sold to customers around the world. The fields of astronomy, imaging, and large

space structures would be interested in such a data processing package. The contractor might want to interface to an existing commercial package such as Matrix X, Control C, or MATLAB and make this package a "toolbox" that would be marketed with the existing software.

AF93-084TITLE: Optical Parametric Oscillator (OPO) with a Diode Laser Pump Source AF93-084TITLE: Optical Parametric Oscillator (OPO) with a Diode Laser Pump Source

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate a tunable OPO using a diode laser as the pumping source.

DESCRIPTION: Recent developments in semiconductor laser diode technology have taken the power output of these devices from the milliwatt into the watt regime. At these power levels, many USAF applications, such as infrared countermeasures (IRCM) and optical communications exist for such a compact, robust source. These applications, however, require sources which are wavelength tunable or, at least, operate at a non-absorbing wavelength in the atmosphere. The current semiconductor materials suitable for high-power diode lasers do not contain bandgaps which allow this. A solution to this problem is to use an Optical Parametric Oscillator (OPO) with the diode laser as the pumping source. The output of this device would be tunable through either temperature- or incident angle-control of the nonlinear crystal. Although OPO's have been demonstrated with several other laser sources, none have been demonstrated with diode lasers. Reasons for this are: (1) High intensities (MW/cm2 range) are required for the nonlinear process of the OPO to occur. The output power of a single laser diode is typically in the MW range; (2) Since the OPO requirements cannot be met with single devices, diode arrays must be used. OPO's also require a clear, nearly diffraction-limited beam over the nonlinear interaction length. The output of such arrays only approaches the diffraction limit when coherence of the entire array is achieved; (3) The beam must be focused to a very small spot to achieve the required OPO intensity level. Focusing the beam this tightly shortens it's Rayleigh Range and, therefore, the effective interaction length. This impacts the overall gain of the OPO since it is a function of the intensity-length product. However, possibilities exist to develop an OPO in nonlinear fibers and waveguides, both of which presently exist.

Phase I: Phase I of this program is to design an OPO which is driven by a diode laser source. The nonlinear crystal requirements to be used per diode type (i.e., 0.7-0.9-micron AlGaAs or 1.2-1.6-micron InGaAsP) will be determined. Examples of such requirements are the transparency wavelength range and the phase-matching wavelength range. Once these parameters have been determined, the appropriate nonlinear materials will be researched, and the proper material or set of material will be determined. Also included in Phase I will be the design of the OPO cavity and any required optics.

Phase II: Phase II should apply the design of Phase I and physically develop an OPO driven by a laser diode source. The development is to include quantification of such figures of merit for an OPO as intensity threshold of the nonlinear process, gain of the device, conversion efficiency from the source wavelength to the desired wavelength, and temperature- and/or angle-tuning parameters of the device. Such an OPO device will be deliverable at the end of the Phase II period. The technology developed has direct impact on the critical Air Force problems of Strategic Relocatable Targets, Secure Optical Communications, and Optoelectronic Warfare. Other USAF and commercial applications of this technology include optical communications, heterodyne detection, and high-resolution molecular spectroscopy.

AF93-085TITLE: Solid State Laser Pumped 3-5 Micron LasersAF93-085TITLE: Solid State Laser Pumped 3-5 Micron Lasers

CATEGORY: Basic Research

OBJECTIVE: Develop an efficient compact 3-5 micron laser optically pumped by an existing solid-state laser.

DESCRIPTION: An ideal laser technology for applications to tactical airborne countermeasures would provide both access to the 3-5 micron spectral region in the near term and later growth to the 8-12 micron band. An appropriate technology must also meet many performance requirements such as pulse energy, repetition rate, size, weight, and reliability. There is currently no clear choice for a fully satisfactory device technology for this application. It is anticipated that the eventual solution will be solid-state lasers pumped with diode laser arrays and perhaps frequency shifted by means of nonlinear optical phenomena, it is not clear that even in the long term NLO techniques will be sufficiently rugged to survive the military environment. However, the compactness, low weight, and higher efficiencies associated with solid-state lasers will make these devices leading contenders for many military applications for years to come. One approach to the 3-5 and 8-12 micron applications are laser-pumped molecules or atoms as a source of infrared laser light. This technique has been shown to be useful for generating laser radiation in specified spectral regions from the visible through the far-infrared. Numerous laser lines in the mid-infrared have been produced using standard lasers to pump common molecules in the gas phase such as CO2, HcO, and NH3. The wavelength range of diode-pumped solid-state lasers can be extended to the 3-5 micron region by using them to pump appropriate molecular gases. Other standard lasers and optical wavelength conversion techniques could be used as well, but size, weight, and efficiency must be considered.

Phase I: The goal of this effort is to determine if a solid-state laser pumped laser is a viable concept for airborne tactical applications both in terms of size, efficiency, and wavelength selectivity. Then, if feasible, a brass board prototype will be built and demonstrated. The end product of Phase I will be a technical report on the methods/techniques to generate a 3-5 micron laser pumped laser (pulsed or DW).

Phase II: The end product of Phase II will be a detailed design, fabrication and experimental testing of the 3-5 micron laser.

AF93-086TITLE: Efficient Cooling of Semiconductor Laser ArraysAF93-086TITLE: Efficient Cooling of Semiconductor Laser Arrays

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate an efficient thermal cooler for high-power diode laser arrays.

DESCRIPTION: Semiconductor laser diode arrays are currently being developed which have output powers in the tens-of-Watts regime, which are increasing at a steady rate. These arrays cover areas on the order of 1 square cm, and the heat dissipation requirements are a major concern in implementation of these devices. The design and demonstration of an efficient semiconductor laser array cooler (SLAC)is sought with the following requirements. (1) The SLAC shall have an areal cooling capacity of 1000 W/sq. cm over a minimum area of 1 sq. cm, and a linear capacity of 100 W/cm for laser diode bars. (2) The thermal tolerance must be +/- 1 K for an operating temperature of 300K. (3) The SLAC must operate over a range from 250K to 350K. (4) The design shall be self-contained, compact and cost-effective to produce. (5) The design shall be capable of operating in zero-g loads for space applications, as well as high-g loads found in tactical operations.

Phase I: Phase I shall be the selection of a technology that fulfills the requirements listed above, and design a SLAC using the technology to meet those requirements. Exploration of new and innovative cooling techniques is encouraged. Micro-heat pipes and Micro-channel coolers are possible solutions to the problem, while other novel technologies will also considered. Once the SLAC design is reached, all fabrication requirements necessary for implementation of the device shall be addressed.

Phase II: Phase II of this program is the implementation of the Phase I design. The implementation shall include the fabrication, test and evaluation of the SLAC device. The test results and a working device will be deliverable upon completion of this phase. Phase III will be the transfer of the program technology to a mission-oriented user for supplying SLAC's, as well as a transfer to, or production for the private sector. The technology developed has direct impact on the critical USAF problems of Strategic Relocatable Targets, Secure Optical Communications, and Optoelectronic Warfare. Other USAF and commercial applications of this technology include optical communications, heterodyne detection, and high-resolution molecular spectroscopy.

AF93-087TITLE: Instrumentation for Aero-Optical ResearchAF93-087TITLE: Instrumentation for Aero-Optical Research

CATEGORY: Basic Research

OBJECTIVE: Develop real-time instrumentation for determining the optical wave-front properties of flows around aerodynamic systems.

DESCRIPTION: The Phase I effort will consist of research in various ways of determining the wave-front distortions, on a continuous, real-time, and temporal basis, generated by turbulent flows on an unaberrated (e.g., planar phase) light beam. There exist methods, such as Holography and Interferometry, which directly measure phase, but they provide only a "snap-shot" view, or are slow enough relative to flow time-scales so as to inaccurately reflect the temporal characteristics of the flow. Past research in turbulent flow has revealed a great deal of temporal and spatial structure; progress in the understanding and design of aero-optical systems depends on accurately determining the effect of the flow structure on light transmission. Thus, the characteristics of aero-optical instrumentation must match those of the aerodynamic flow-field. Flows of immediate USAF interest involve convective velocities of up to 300m/s ans spatial scales down to 0.01m. Thus, the instrumentation must be capable of sampling, without aliasing effects, events with time-scales on the order of 30 microseconds. The instrumentation must be compatible with wind-tunnel experiments and must provide digitized data for computerized post-processing and analysis. The end results are the spatial and temporal characteristics of the flow-field. These can include, but are not necessarily limited to, spatial correlations, phase-maps, jitter, and bore-site error. The system must be capable of being integrated with fluid mechanical diagnostic instrumentation (e.g., cold or hot-wire probes) so a direct link of high temporal resolution may be made between the fluid mechanics and the resulting optics. Beam diameters, scaled by the flow-field dimension (z) range from z/10 to 10z, and the electromagnetic spectrum ranges from visible to IR.

Phase I: This Phase will, at a minimum, include research towards the selection of the best candidate method for determining optical wave-front properties of flows around aerodynamic systems and the preliminary instrumentation designs. Phase II: Phase II will be the demonstration of the system on high-subsonic flow about a cylinder, with and without a trailing edge splitter plate. Phase III would provide a follow-on system for transition to wind-tunnels for use by program offices, laboratories, and other organizations such as NASA. This topic is important because of the renewed emphasis that aero-optics is receiving in Air Force Research and Development. This emphasis stems from such applications as imaging through flight vehicle flow-fields (as in Long Range Oblique Photography) and the projection of laser beams for both active imaging and target destruction (as in Theater Missile Defense). Improved aero-optical instrumentation capable of rapidly measuring wave-front distortions and determining spatial and temporal scales is critical, first to the adequate understanding of the light transmission problem and then to the development and design of future systems which are subject to aero-optical effects.

AF93-088TITLE: USAF - Phillips Laboratory; Technology TransferAF93-088TITLE: USAF - Phillips Laboratory; Technology Transfer

CATEGORY: Advanced Development

OBJECTIVE: Assess DOD and commercial applications, determine required refinements and build prototype based on immature technologies originating at the Phillips Laboratory.

DESCRIPTION: The Phillips Laboratory (PL) is the premier DOD organization conducting R&D in military space, missiles, directed energy, and geophysics technology. Ongoing or previous R&D efforts at or on behalf of the PL often result in specific state-of-the-art technological innovations which, due to USAF priorities, are not developed to maturity. Many of these technologies, if properly developed and refined, may offer truly innovative solutions to a great many DOD and commercial requirements. The following subtopics describe specific immature technologies with potential military and commercial applications. Contractors may contact the Defense Technical Information Center (DTIC) for technical information packages which support these subtopics. This topic and the specific subtopic must be

identified by topic number and title on all related requests submitted to DTIC and on contract proposals submitted to the PL.

Phase I: An in-depth assessment of potential commercial and military applications will be required. As a result of this assessment, determine and design the initial necessary refinements.

Phase II: Based on the original PL immature technology, the commercial/military applications assessment, and the design refinements, build or fabricate, test and validate a laboratory demonstration model or prototype.

A. ADVANCED FIBER COUPLED SEMICONDUCTOR LASERS; HIGH POWER DEVICES: Numerous applications including illumination, countermeasures, friend or foe identification, medicine, and materials processing can be significantly improved by using high power laser arrays with fiber optic output couplers. Devices capable of delivering 50-100W in 800 -900nm at the fiber output are required. The Phillips Laboratory (PL) has developed unique expertise in the field of "diode lasers" and that expertise will be placed at the contractor's disposal. The Phase I technical effort should concentrate on developing designs to reach high powers in compact packages, with a proof of concept demonstrator, at the 10W level, delivered upon completion. In Phase II a 50-100W demonstrator shall be developed and delivered for field evaluations.

B. ADVANCED FIBER COUPLED SEMICONDUCTOR LASERS; ALTERNATE WAVELENGTH DEVICES: Numerous applications including illumination, countermeasures, friend or foe identification, and materials processing, can be significantly improved by using advanced sources providing visible and min-infrared light from fiber optic coupled semiconductor lasers. The Phillips Laboratory has developed unique expertise in the field of "diode Lasers" and that expertise will be placed at the contractor's disposal. Phase I technical efforts should include developing designs for visible, blue-red, laser arrays providing 10W fiber output and mid - infrared 2-5 micron laser arrays providing 10W fiber output. The proof of concept demonstrator at1-2W/2Microns will be delivered. Phase II should develop and deliver a 10W, 670nm red demonstrator and a 10W, 2 Micron infrared demonstrator4for field tests.

C. PASSIVE WIDEBAND ELECTROMAGNETIC FIELD SENSORS: There is an interest in devising RF sensors, for use in low power microwave (LPM), high power microwave (HPM), and ultrawideband (UWB) applications, that will perform at higher frequencies and wider bandwidths (at least 10GHz)than what are currently available. Alternatives, to the traditional multi-gap and asymptotic conical dipole geometries for detecting and monitoring continuous-wave and transient electromagnetic phenomena, are desired. In addition, schemes employing direct modulation of diode lasers are not desirable because of their bandwidth and dependence on embedded microwave circuitry at the sensor. Ideally, the sensors will be physically small and will be fabricated/assembled from materials that will minimally perturb the fields to be measured. The transmitter, data link, and receiver should have minimal insertion loss. Presently, efforts are underway to explore and develop sensor alternatives to the technologies mentioned above. Pending the results of current in-house research, manufacturing and fabrication techniques29 and methodologies will need to be identified and implemented. The prototype envisioned will most likely incorporate various optoelectronic and related technologies. Modifications may be made to sensing schemes with regard to packaging considerations. However, an emphasis on novel configurations employing LiTaO3 or LiNbO3 should be given serious consideration. It is also expected that performance characteristics will be maintained. Typical bandwidths will exceed those mentioned above with dynamic ranges of at least three decades or more. Typical power densities might be micro W/sq. cm to mW/sq. cm for LPM and tens of W/sq. cm to several kW/sq. cm for HPM. Low power microwave, high power microwave, and ultrawideband testing must be performed on sensors in various stages of development or packaging. Laboratory facilities, with these capabilities, can be made available subject to negotiations.

AF93-089TITLE: Workstation Based Interactive Space Sensor Systems Simulation PackageAF93-089TITLE: Workstation Based Interactive Space Sensor Systems Simulation Package

CATEGORY: Basic Research

OBJECTIVE: Develop and deliver an easy to use simulation package for rapid concept exploration which includes both orbit and utility analysis.

DESCRIPTION: Many different simulation packages currently exist on sensors, orbit analyses, and systems analyses. However, an integrated simulation more than often requires large amounts of overhead support. This support includes items such as data file preparation, data entry and verification, large run times on large systems, interpretation of results, and feeding of interpreted results to a different system for display. Thus, it takes weeks of work and a significant amount of manpower just to run one simulation. As a result, both time and costs of such systems make them impractical for rapid concept exploration use. Moreover, data interfaces probably do not support easy information exchange. In rapid concept exploration situations, a user must be able to perform rough order system level trades quickly and pass on the results to the interested community by way of a working model. Consequently, a stand-alone and easy to use simulation package with the following characteristics can provide an extremely useful tool in the area of rapid concept exploration.

Characteristics:

1. User can interactively run many simulations with the ability to vary the parameters without any overhead support.
2. Combines orbit analysis, sensor performance estimation, and utility analysis.
3. Provides immediate display and hard copy of usable outputs.
4. Supports easy and standardized information exchange.

Phase I: Efforts in Phase I shall include defining, in detail, the capabilities of this simulation package. The definition must include developing performance specifications, setting data interface standards, collecting models, identifying possible available software for modification/integration, and propose the target platform.

Phase II: The second phase efforts shall produce the actual package with associated documentation. Also required will be the initial user training and training materials.

AF93-090TITLE: Methane ArcjetAF93-090TITLE: Methane Arcjet

CATEGORY: Basic Research

OBJECTIVE: Determine the magnitude of the sooting problem in methane arcjets.

DESCRIPTION: Chemically powered orbit transfer vehicles can deliver only 40 percent of the initial low earth orbit mass to geosynchronous orbits. Electric rocket engines can double the mass delivered to geosynchronous orbits. Electric rocket engines can double the mass delivered to geosynchronous orbit. These high performance engines use one-half to one-third the propellant of chemical engines and this reduction in propellant mass enables a corresponding increase in payload. The most technically mature electric rocket is the low- impedance ammonia arcjet . However, its performance is limited to a maximum specific impulse of 820 seconds and an efficiency of 35 percent. This project will examine the potential of using methane as an arcjet propellant instead of ammonia. Methane holds great promise as a propellant because it has the same store ability properties which make ammonia attractive with a high thruster performance potential close to hydrogen without the storage problems associated with hydrogen.

Phase I: This SBIR will determine if there are any sooting problems associated with the use of methane and to provide innovative techniques to eliminate the sooting caused when the arcjet uses methane as a propellant. Suggested techniques for determining if sooting is a problem are using an arcjet adapted to use methane or using a simplified electrode configuration which simulates an arcjet. Proposals are not limited to these suggested approaches, but will be required to prove that any proposed approach accurately simulates an arcjet's operating conditions. The reference arcjet for this evaluation shall be the 26-kilowatt ammonia thruster developed by the USAF's Phillips Laboratory.

Phase II: This will fabricate and test a thruster on a thrust stand to verify methane performance and lifetime.

Phase III: It will concentrate on commercially developing the methane arcjet for use as primary or secondary propulsion on commercial satellites. Proposals will be judged on understanding the problem, demonstrated expertise in the field, and innovative approaches.

AF93-091TITLE: Novel Synthesis of Cubane PrecursorAF93-091TITLE: Novel Synthesis of Cubane Precursor

CATEGORY: Basic Research

OBJECTIVE: Develop a Novel, Low Cost Synthesis for Cubane Dicarboxylic Acid.

DESCRIPTION: The chemical compound cubane (C8H8) and its derivatives methyl cubane and dimethyl cubane are of interest as additives to or replacements for the kerosene-based rocket propellant RP-1. Cubane and its derivatives are synthesized from cubane dicarboxylic acid. However, the best reported syntheses of cubane dicarboxylic acid involve seven or eight chemical reactions, many of which are difficult to scale up, expensive, or relatively low yielding. A totally new synthetic route to these cubane derivatives is needed. It is desirable that the new process involve less than four steps, starting within expensive, readily available materials. Further, it is desirable that the synthesis require limited workup and purification between steps.

Phase I: This effort should be directed at identifying alternative synthetic pathways and techniques.

Phase II: This will emphasize production of 10-100 g lots in the laboratory using less than one man month of effort; a production cost analysis will also be performed.

Phase III: This effort will focus on commercial applications of adapting cubane and its derivatives as rocket fuels or fuel additives.

AF93-092TITLE: Prototype Storage and Delivery Device for Cryogenic Solid Hydrogen PropellantsAF93-092TITLE: Prototype Storage and Delivery Device for Cryogenic Solid Hydrogen Propellants

CATEGORY: Basic Research

OBJECTIVE: Develop a Cryogenic container capable of storing and delivering cryogenic hydrogen solids into a combustion chamber.

DESCRIPTION: Cryogenic solid propellants may provide revolutionary advances in rocket propulsion. Solid hydrogen and mixtures of energetic atoms or molecules with solid hydrogen are relatively difficult to form and store for long periods of time. Innovative approaches to the storage and transfer of these cryogenic solids are needed. If these cryogenic hydrogen based fuels are to be useful for rocket propulsion, a storage and delivery device needs to be developed that will have the following characteristics: a) Must be capable of condensing gaseous hydrogen directly into the solid state at a temperature less than 10K(-263 degrees C), b) The cryogenic solid must have a usable lifetime of at least one hour, c) The container must store at least one gram of cryogenic solid, d) Optical inspection windows shall be included to determine the content of the storage container, e) Some method of delivering cryogenic material into a combustion chamber must be developed and included in the storage of the container, f) Avoidance of the liquid state is required in the transfer method, especially when energetic atoms or molecules are a component of the cryogenic solid mixture, and g) The flow rate into the combustion region must be controllable. The pressure of the transferred material must be greater than atmospheric pressure and ultimately must be compatible with the rocket combustion chamber.

Phase I: The results of this Phase I effort must include a detailed practical design.

Phase II: This effort will also include a detailed practical design to be built in this Phase II.

Phase III: These efforts will focus on the development and testing of larger scale propulsion systems based on the Phase II results, with subsequent transition of this technology to the industrial propulsion community.

AF93-093TITLE: Critical Technology Demonstration for Pulsed Plasma PropulsionAF93-093TITLE: Critical Technology Demonstration for Pulsed Plasma Propulsion

CATEGORY: Basic Research

OBJECTIVE: Demonstrate the scale ability and performance of a megajoule class Magneto plasma dynamic (MPD) plasma thruster.

DESCRIPTION: The extension of small anode centered, MPD plasma thrusters to useful energy levels above 1 megajoule has been limited because of unforeseen adverse operational characteristics such as parasitic currents. Below 500 kilojoules, scaling and system operation give predictable performance. Thus, a gap exists between the desired operating regime and the experimental limit. Continued work by a number of researchers over the last five years has led to a better understanding of the arc physics, and a number of promising solutions to the parasitic current problem, such as field distortion elements (FDE's), have been successfully tested at low energy. Therefore, it is desirable to test a thruster in the 1 to 10 megajoule regime to extend the scaling laws and verify that the operational difficulties have been corrected.

Phase I: This should be a limited effort consisting of facility definition and preparation, diagnostic development, and testing of a scaleable 100 to 500 kilojoule MPD plasma device in order to provide confidence in the approach proposed for Phase II.

Phase II: It consists of the development, modeling, and demonstration of a full scale, megajoule plasma device. Proposals will be judged upon insight and understanding of the problems, demonstrated expertise in relevant fields, qualifications of the proposed team, facilities, strength and logic of the proposed program, organizational structure and management approach, and overall quality of the proposal.

Phase III: It should open the door to many applications, such as compact, high performance space propulsion and power devices for the Air Force's mission in space; and neutron radiographic imaging, high-resolution x-ray lithography, and production of short life isotopes for medical application for commercial ventures.

AF93-094TITLE: Advanced Electric Propulsion InsulatorsAF93-094TITLE: Advanced Electric Propulsion Insulators

CATEGORY: Basic Research

OBJECTIVE: Develop New Insulator Materials for Use in Electric Propulsion Thrusters.

DESCRIPTION: Chemically powered orbit transfer vehicles can deliver only 40 percent of the initial low earth orbit mass to geosynchronous orbits. Electric rocket engines can double the mass delivered to geosynchronous orbit. These high performance engines use one-half to one-third the propellant of chemical engines and this reduction in propellant mass enables a corresponding increase in payload. Critical to achieving operational status for these thrusters is the development of ultra-high temperature insulators from which thrusters can be fabricated. The goal of this SBIR is to develop materials with continuous operating temperatures of not less than 3000 degrees centigrade, good machinability, durability, high thermal conductivity, and high electrical resistance.

Phase I: It will identify and evaluate available and new materials.

Phase II: It will focus on obtaining and testing the most promising candidates in operational thrusters.

Phase III: It will concentrate on the commercial development of these insulators for applications such as in electric thrusters or high power switches. Proposals will be judged on understanding the problem, demonstrated expertise in the field, and innovative approaches.

AF93-095TITLE: Treatment of Nitrate and Mixed Nitrate/Sulfate Contaminated Waste WaterAF93-095TITLE: Treatment of Nitrate and Mixed Nitrate/Sulfate Contaminated Waste Water

CATEGORY: Basic Research

OBJECTIVE: Develop a process to treat waters containing high concentration of nitrates and mixed nitrate/sulfate to enable reuse of the waste water or, as a minimum, permit dumping to grade.

DESCRIPTION: A Second Stage nitrogen tetroxide vapor scrubber system is currently in pilot stage of development and is anticipated to be in the field in early 1993. This system, which is designed for use in series with the current sodium hydroxide/water vapor scrubbers currently installed at both East and West coast space launch facilities, uses a blend of sodium hydroxide and sodium sulfite in water as the scrubbing liquor. Significant quantities of waste waters

containing high concentrations of nitrates and mixtures of nitrates and sulfates, which currently must be shipped off base for treatment and/or disposal, will be produced by these devices during propellant servicing of the launch vehicles and payloads. The Stage I scrubber has about a 2500 gallon capacity; Stage II will be about 300 gallons. An effective and economical process to treat these waste waters on site is needed to permit recovery and reuse of the water or safe release to the environment. The waste waters would contain a mixture of sodium hydroxide, nitrate and nitrite in the case of the Stage I scrubber, and sodium hydroxide, nitrates, nitrites, sulfite, sulfate, and other sulfur containing compounds in the case of the Stage II scrubber.

Phase I: This consists of developing the required chemistry and processes for neutralizing and detoxifying the waste waters (e.g., chemical, catalytic and biological processes are potential approaches)and preliminary design of the associated process hardware. Laboratory research using actual samples of waste waters would be conducted to characterize the process parameters and develop design criteria for the Phase II Pilot Scale process demonstration.

Phase II: This would consist of the design, fabrication and demonstration testing of a pilot scale process developed in Phase I. This testing would be designed to further characterize the process and to develop scaling criteria and process control criteria. Testing would successfully demonstrate the efficiency of the process using a variety of actual wastes and would provide the basis for economic assessment of the process.

Phase III: This would demonstrate the process operation in prototype, full scale hardware, interfaced with a selected on-site operation.

AF93-096TITLE: High Emissivity Surface Treatments for Arcjet ThrustersAF93-096TITLE: High Emissivity Surface Treatments for Arcjet Thrusters

CATEGORY: Basic Research

OBJECTIVE: Develop long-life surface treatments for arcjet thrusters.

DESCRIPTION: Chemically powered orbit transfer vehicles can deliver only 40% of the initial low earth orbit mass to geosynchronous orbits. Electric rocket engines can double the mass delivered to geosynchronous orbit. These high performance engines which use one half to one third the propellant mass enable a corresponding increase in payload. The most technically mature electric rocket is the low impedance ammonia arcjet. However, its performance is limited to a maximum specific impulse of 820 seconds and an efficiency of 35%. This project will develop and test new techniques and/or materials to increase the emissivity of the tungsten anode of an arcjet enabling it to operate at higher power levels with improved performance.

Phase I: It will determine which techniques and materials offer the greatest emissivity at the operating temperature of a 26-kilowatt ammonia arcjet's anode and will test the most promising concept or concepts. Suggested concepts are deep threading of the outer surface of the anode, high emissivity coatings, or a combination of both. Proposals are not limited to these suggestions. The use of an arcjet is no required for Phase I, but the proposer must verify that the arcjet simulator produces the same conditions experienced by a 26 kilowatt low-impedance ammonia arcjet.

Phase II: This will involve the construction of an arcjet using the most advantageous surface treatment and testing the thruster on a thrust stand to verify its performance and determine its life time.

Phase III: It will concentrate on commercially developing this technique for possible use on high temperature space radiators. Proposals will be judged on understanding of the problem, demonstrated expertise in the field, and innovative approaches.

AF93-097TITLE: Infrared all Sky ImagerAF93-097TITLE: Infrared all Sky Imager

CATEGORY: Basic Research

OBJECTIVE: Develop an infrared all sky imaging system to measure cloud spatial, temporal, microphysical, and optical properties.

DESCRIPTION: The design of a novel infrared all sky imaging system for the detection and determination of cloud spatial, temporal, microphysical, and optical properties is solicited. Clouds in either the foreground, that is between the sensor and the target, or in the background, behind the target, can limit the effectiveness or even render inoperable Air Force (AF) systems. Clouds are frequently sited as one of the DOD areas requiring a significant amount of new research. To truly understand how clouds affect AF Electro-Optical (EO)systems, it is necessary to fully understand cloud radiative properties and their radiative interactions with the surrounding environment. This understanding will only be obtained when we can fully describe the cloud spatial, temporal, microphysical, and optical properties. The use of infrared focal plane array technology to develop a day and night time all sky imaging capability should be considered. The infrared imaging system is not restricted to the long wavelength infrared atmospheric window spectral region. The possibility of using specific infrared spectral band information in either of the two broad band atmospheric windows to obtain cloud microphysical and optical properties should be considered.

Phase I: Phase I of this SBIR effort should investigate the feasibility of developing an automated all sky infrared imaging system and the feasibility of using infrared all sky imagery to obtain cloud microphysical, optical and/or radiative properties.

Phase II: Dependent upon and based on the Phase I results, a prototype all sky infrared imaging system will be fabricated and the algorithms to analyze the infrared imagery to obtain the desired cloud properties will be developed and delivered to the Air Force in Phase II. This phase should also include a short duration data collection period and the subsequent data analysis to evaluate the imager performance.

Phase III: Again, based on the result of the first 2phases, a relatively inexpensive automated operational all sky infrared imaging system, to include a data logging and data analysis capability, will be developed. The algorithms used to analyze the imagery should be fully validated during Phase III.

AF93-098TITLE: Multipath Correction for Global Positioning System Satellite Range Measurements AF93-098TITLE: Multipath Correction for Global Positioning System Satellite Range Measurements

CATEGORY: Basic Research

OBJECTIVE: Develop new approaches to real-time multipath correction for Global Positioning System ionospheric and satellite range measurements.

DESCRIPTION: New and creative approaches are solicited for real-time correction of multipath errors in Global Positioning System (GPS) ionospheric and satellite range measurements from stationary dual-frequency precise-code GPS receiver systems. Multipath(reflections) from objects near the receiver antenna can cause substantial errors in the receiver's measurement of ionospheric total electron content and satellite range. The multipath errors can exceed the ionospheric errors which the second GPS frequency was incorporated to correct in satellite range measurements. Such multipath errors can have a detrimental effect on GPS precise positioning, ionospheric measurements, surveying, and other applications. GPS multipath is particularly insidious, in that it will degrade system performance while giving little indication of the source of the problem without use of specialized tests. What is desired is a system approach that will automatically correct for multipath to a level of accuracy and antenna coverage much greater than existing approaches, without requiring any specialized knowledge on the part of the operator. Application of such an approach in ionospheric measurements, for example, could extend low elevation capability from 15 degrees nearly to the horizon - nearly doubling the geographic coverage, allow regular use of inexpensive antennas, and greatly simplify siting requirements. Such an improvement would be a significant benefit to the Air Force effort to use GPS technology to measure ionospheric range errors for making corrections to space surveillance and early warning radars. An example of acceptable performance would be a technique that within a short time of GPS receiver installation, for example 3 days, would automatically acquire knowledge of the local multipath and would then correct multipath in real-time for all subsequent data. One present technique, limiting antenna sensitivity at lower elevation angles, is effective at reducing the strength of many multipath signals - but at the expense of unacceptably reducing the receiver's spatial coverage (by one third or more). Other techniques that combine average differential carrier phase and differential group delay to reduce multipath in ionospheric electron content measurements typically provide good correction only when a long period (more than 1 hour) of data is averaged. Such an approach cannot be effective for the half of the

low-elevation coverage where the satellite is rising.

Phase I: Efforts in Phase I should result in the development of the proof-of-concept of the approach.

Phase II: In Phase II the contractor shall design an engineering model system and demonstrate the concept. Potential exists to incorporate innovative approaches in GPS receiver firmware, or in an adjunct PC/notebook computer that could be transparent to users of GPS receiver's data output. Therefore, particular attention will be given to straightforward or simple-but-elegant approaches that are more readily implemented in such technology.

AF93-099TITLE: Ion Composition Detection in High Temperature PlasmasAF93-099TITLE: Ion Composition Detection in High Temperature Plasmas

CATEGORY: Basic Research

OBJECTIVE: Develop new innovative approaches for measuring positive and/or negative ion concentrations in high temperature, dense and/or tenuous plasmas of atmospheric origin.

DESCRIPTION: An important focus of current research in the USAF is the effect of high temperature plasmas on the environment and operation of USAF systems and space vehicles. Sheath and wake plasmas associated with re-entry and hypersonic vehicles, jet engine exhaust, and rocket plumes both in the atmosphere and in space are examples of high temperature plasmas that can interfere with radio wave propagation (e.g., communications blackout) and can significantly alter the detectability of the vehicle (e.g., radar cross sections). The properties of these plasmas, in particular the electron density, are typically calculated with chemical kinetics computer codes that are based on kinetic data taken at laboratory temperatures lower than the plasma temperature. Ion composition data from the actual high temperature plasmas are essential as a benchmark for the validation of the code predictions and for development of alleviative measures. Proposals for innovative techniques for sampling the ion composition of these high temperature plasmas are solicited. A list of design goals for an instrument or technique is given below. To insure overlap with existing research efforts , proposals for small, quadruple type mass spectrometers that could easily be adapted to a variety of environments (ground-based tests of flames, plasma arcs, jet and rocket engines, and space-based tests on sounding rockets, satellites and the space shuttle) are particularly encouraged. Proposed techniques need not be limited to quadruple mass spectrometry. The design and construction of an instrument to sample ion composition in the severe environments outlined in the "design goals list" obviously involves solutions to many challenging technical and scientific problems, including miniaturization of the mass spectrometer or other diagnostic, heat shielding, differential pumping, ion transport and reactions through shock waves, debye sheaths or pressure/temperature/plasma density gradients, calibration, and so on. Since solution of all of these problems may be beyond the scope of the current solicitation, proposals which address one or more of the issues, but do not reach the point of providing a completed instrument, are welcome. DESIGN GOALS: Ion Composition Measurements in High Temperature Plasmas NOTE; proposed instruments do not have to meet the full dynamic range listed for all conditions. Instruments or techniques which address aspects of the ion sampling problem but not the entire problem are welcome.
Type of Data Required: Total number density of positive and/or negative ions, identity of individual ion species and their concentrations.
Mass Range of Ions:1-200 atomic mass units (amu)
Mass Resolution:Single mass resolution across mass range.
Temporal Resolution:one full mass spectrum per second.
Ion Density Range:1E5 to 1E13 ions cc.
Neutral Gas Pressure Range:atmospheric pressure to high vacuum.
Neutral Gas Temperature Range: 300 - 2500K.
Neutral Gas Flow Velocity: 0 - Mach 5.
Instrument Size*: 4" dia by 12" long.
Instrument Weight*: 5 lbs.
Measurement Accuracy+/- 30% for major ions, and+/- factor of 3 for minor ions.
*excluding vacuum housing, heat shields, etc.

Phase I: Conduct and complete instrumentation design efforts.

Phase II: Construct, test and deliver instrumentation for use in plasma sampling experiments.

AF93-100TITLE: Numerical Weather Prediction Modelling via Massively Parallel Computing AF93-100TITLE: Numerical Weather Prediction Modelling via Massively Parallel Computing

CATEGORY: Basic Research

OBJECTIVE: Develop computational structures and algorithms for limited area, grid point models to exploit the efficiencies of highly granular multi-processors.

DESCRIPTION: Evolving military concepts of operations in the wake of the Desert Storm experience and the substantial restructuring and downsizing of force structure due to the end of the Cold War are markedly changing the needs for, and the nature of, operational weather support in the USAF. The need to develop a Tactical Forecast System (TFS) to support contingencies that could occur through the concept of Global Reach - Global Power is a priority for the USAF R&D community. Tomorrow's TFS will be driven, in large measure, by a mesoscale (limited area) numerical weather prediction model(s) (NWP) embedded in a computer architecture compatible with the need for compactness and transportability in battlefield scenarios. Finely grained multi-processing computer systems (with up to several thousand individual processing units linked together) offer the potential of satisfying TFS needs. However, there has not been, to date, a robust performance demonstration of representative mesoscale NWP grid point models in a massively parallel computing environment using, for example, conventual shared-memory algorithms on a standard operating system such as UNIX. The approach for such a task should exploit the local connectivity nature of grid-point models to minimize the search of a small data set in a large data base.

Phase I: During the Phase I effort, one could either construct or choose an existing simple and yet realistic NWP model for experimentation. If an existing model is adopted for the pilot project, certain reprogramming may be needed. But even in the initial phase, the model should be placed in a program environment to take advantage of conventional software tools, off-the-shelf graphics, and user interfaces such as the X Window System.

Phase II: In Phase II, the validated massively parallel algorithms will be implemented for an operational-type mesoscale NWP model (e.g. Madala & Chang). Test cases shall be conducted on the final version of the model to demonstrate model performance.

AF93-101TITLE: High Resolution Ultraviolet SensorAF93-101TITLE: High Resolution Ultraviolet Sensor

CATEGORY: Basic Research

OBJECTIVE: Develop a high spatial resolution ultraviolet sensor suitable for a space vehicle.

DESCRIPTION: Innovative approaches are solicited for the development of an ultraviolet imager that is suitable for a space vehicle for the detection and tracking of space objects. Mid and near UV wavelengths are to be considered. Currently employed UV imagers have as their main components a collecting telescope, an intensifier, and a CCD video camera. In such an imager the greatest loss in spatial resolution is in the intensifier. But an intensifier is used for the detection of weak sources. How to overcome this problem is the nature of this topic.

Phase I: Efforts in this phase shall consist of the investigation of concepts that may have the potential of overcoming the above problem. This effort is primarily theoretical but any laboratory work proposed to support a concept is welcomed.

Phase II: Efforts in the second phase shall consist of research leading to the design of the desired sensor, a laboratory model of the sensor and the testing of the sensor characteristics.

AF93-102TITLE: Heated Cloud Rise ModelAF93-102TITLE: Heated Cloud Rise Model

CATEGORY: Basic Research

OBJECTIVE: Develop a computer model suitable for predicting the stabilization height, dimensions, and position of a large, thermally buoyant cloud.

DESCRIPTION: A computer model is needed for predicting rise rates, stabilization heights, dimensions, and positions of large, thermally buoyant clouds. Such clouds are produced during the testing and launching of space launch vehicles. Output from the cloud rise model will initiate atmospheric dispersion modeling of down wind cloud concentrations. The model needs to account for several types of cloud sources such as nominal launches, nominal ground tests, propellant burns, and vehicle aborts. The model must consider cloud interaction with inversion layers, wind shears, and other relevant meteorological factors at the release site. It also must account for chemical reactions occurring within the cloud that will effect cloud rise.

Phase I: The desired Phase I product is a preliminary computer code suitable for evaluation.

Phase II: The desired Phase II product is a completed and validated computer code capable of providing specific cloud stabilization height, dimension, composition, and position information.

AF93-103TITLE: Closed Cycle, Closed Loop Multi-Functional Cleaning MachineAF93-103TITLE: Closed Cycle, Closed Loop Multi-Functional Cleaning Machine

CATEGORY: Basic Research

OBJECTIVE: Design and construct an innovative, totally enclosed, recyclable, multi-functional cleaning machine.

DESCRIPTION: A drop-in freon solvent substitute for precision cleaning of strategic guidance systems is yet to be found. CFC-113 (freon) another ozone layer depleting substances (OLDS) are being phased out ata rate that is much faster than originally planned. As new information on ozone layer depletion is acquired the phase out rate increases. Many of the potential fluorocarbon substitutes for freon are very expensive, $12 to $25 per pound. Membrane filters are available that will filter out solvents, return the filtrate to the system, and expel environmentally acceptable air. These filters are as efficient in separating OLDS as they are in separating the new expensive solvents. Sweep frequency ultrasonics have been shown to be most effective as cleaning mechanisms, and have been shown to be safe to use in cleaning electronic hardware. New Fluorocarbon surfactants have been shown to be more effective than freon as particulate contaminate removal agents, particularly when used in connection with the new ultrasonic transducers. Super critical fluid cleaning processes (particularly super critical CO2) have been shown to be most effective in cleaning metal parts of hydrocarbon and bromine fluid contaminates. SC CO2 processes have been developed to clean complex metallic/epoxy containing parts and remove absorbed CO2 from the epoxy components (if removal is required). All these developments now make it possible to design, fabricate, test and place in production an innovative multi functional cleaning system that will allow the cost effective use of the new expensive solvents, that will facilitate application of new processes and even allow the use of stockpiled OLDS in an environmentally acceptable manner. A suggested philosophy of design is to bring the cleaning mechanism to the part to be cleaned rather than bringing the part to the cleaning mechanism.

Phase I: Efforts will include complete design together with selected feasibility demonstrations.

Phase II: Efforts will include the fabrication, testing, and placing the multi functional machine in use in a production environment.

AF93-104TITLE: Manufacture of Stator and Rotor Laminations/Cores for Missile SFIR Assembly AF93-104TITLE: Manufacture of Stator and Rotor Laminations/Cores for Missile SFIR Assembly

CATEGORY: Basic Research

OBJECTIVE: An innovative process for the manufacture of SFIR stator and rotor laminations/cores used in missile

guidance systems.
DESCRIPTION: An innovative/efficient manufacturing process is required for manufacture of precision stator and rotor laminations/cores used in strategic guidance system components. The laminations are made from cold rolled sheet nickel-iron alloy, ranging from 0.003 to 0.010 inch in thickness, and displaying specific magnetic properties. Sizes range from 1 inch to 2.5 inches in diameter and tolerances of +/- 0.001 inch are common place. Current methods of manufacture are photo etching and precision stamping, together with required de burring and other finishing processes. Electric discharge machining and laser cutting are not acceptable on the basis that these methods alter the electromagnetic properties of the material. Alternate cost effective (small volume) high precision methods of manufacture should be investigated. Final vendor approval by the responsible Air Force Design Activity will be necessary. The background document relating to this SBIR solicitation topic provides examples of the required SFIR laminations/cores and responsible Air Force Design Activity contact. Potential SBIR contractors are advised that portions of the background statement contain documents that are subject to EXPORT CONTROL LAWS and procurement of the background statement places the recipient under appropriate restrictions. The DTIC background document related to this solicitation topic contains instructions for U.S. citizens to obtain the export control related background document. The following statement will appear on the background paper:

"This document contains information for manufacturing or using munitions of war. Export of the information contained herein, or release to foreign nationals within the United States, without first obtaining an export license, is a violation of the international traffic in areas regulation. Such a violation is subject to a penalty of up to 2 years imprisonment and a fine of $100, 000 under 22 USD 2778."

Phase I: Efforts in this phase will include investigation of potential manufacturing processes together with demonstration of the applicability of the selected process in concurrence with the responsible Air Force Design Activity.

Phase II: This follow-on phase shall result in the manufacture and approval selected rotor and stator laminations and cores.

AF93-105TITLE: Reentry Environment PhenomenologyAF93-105TITLE: Reentry Environment Phenomenology

CATEGORY: Basic Research

OBJECTIVE: Develop Hypersonic Reentry Phenomenology Related to Methodology of Compensation Capability to Enhance Electromagnetic Transmission for Advanced System.

DESCRIPTION: Future reentry systems may be incorporating sensors to fulfill mission requirements. Development of techniques for employing advanced sensors and guidance in the hypersonic reentry environment meets with many significant challenges. At a minimum, antenna window heating and the resultant changes in the electromagnetic properties, antenna material ablation and local plasma are all key factors in the operation of a sensor. Approaches are sought which would lead to methodology or compensation capability which could alleviate the effects of reentry on RF transmission.

a. For example, employment of a strong magnetic field around an antenna window might be feasible with room temperature super conductor materials. Other techniques including material ejectants or alternate concepts may also be candidates.

b. Another approach which may be included in the sensor system concepts is the compensation for the environment that accompanies hypersonic reentry. Options for local environment sensing might be integrated into a sensor system allowing for real-time compensations to be included sensor updates. Options to be considered should include the ability to compensate for temporal as well as spatial effects of the hypersonic reentry environment over the sensor aperture.

c. Development of sensor systems for hypersonic reentry will need to be supported by effective and cost efficient ground test capabilities to support test and evaluation short of full scale flight test. The test conditions that need to be simulated are the boundary layer fluid, thermal and plasma profiles to sufficient fidelity to allow antenna window sensor testing during simulated environmental conditions.

d. Analyze available reentry vehicle flight data to provide an understanding of flow field plasmas for hypersonic

vehicles at angle of attack. Non-zero angles of attack can produce significantly higher plasma on the vehicle lee side for simple conic geometries. However, the lee side from a standpoint of lower heating is a likely location for antenna windows. Additionally, in the lower altitude regime turbulent flow characteristics need to be included. Further, the effort should explore these concepts and how they would translate to analyzing more advanced configurations of a lifting body or glide vehicle.

Phase I: The first phase efforts would explore several alternatives and provide strong and weak points.

Phase II: Efforts in the second phase would develop the chosen methodology and provide a proof of concept in a ground test facility.

AF93-106TITLE: Innovative Navigation for ICBM ApplicationsAF93-106TITLE: Innovative Navigation for ICBM Applications

CATEGORY: Basic Research

OBJECTIVE: Identify and investigate alternative guidance and navigation sensors, update schemes, and processors for ICBM applications.

DESCRIPTION: The following subtopics cover specific areas of interest. Note, proposals must specify subtopic by both topic number and subtopic letter designation.

A. Navigation Update Sensors: Strategic grade inertial instruments are complex and very expensive. As a result, strategic guidance and navigation systems relying solely on inertial instruments for navigation are difficult to acquire, maintain, and service. If this reliance on purely inertial reference is reduced, a potential savings in cost and complexity arises. Several techniques have been proposed to this end, including stellar, radar, and satellite navigation updates; however, new and innovative sensors are still being sought.

Phase I: Attempt to identify additional update schemes or sensors and perform a sound analysis illustrating the feasibility and potential accuracy of each component.

Phase II: Involves further investigation, exploratory testing, or simulation as necessary to demonstrate the proposed concept.

B. Guidance And Navigation Signal Processors: With the inclusion of update information, as described above, the load on the guidance computer becomes markedly increased. Efficient algorithms are required to incorporate navigation updates, making best use of processor capability. More efficient processing of update and inertial sensor data is also of interest. Parallel processors and neural networks are examples of architectures that could be applied to many functions of guidance, navigation, and control.

Phase I: Present an innovative approach to the problem of processing the data required of an advanced ICBM guidance system or some component thereof.

Phase II: Includes further investigation, testing, and simulation demonstrating the proposed concept.

C. Optical SAR Processing: Future ICBM reentry systems may incorporate advanced SAR sensors. These sensors must be able to process data in real-time in order to be useful in a hypersonic vehicle. SAR processing is characterized by transforms that are well suited to optical or hybrid processors. These processors must survive and operate in the harsh, high temperature and acceleration environment of a reentry vehicle when used in an ICBM application.

Phase I: The objective shall be the definition of an optical or hybrid processor tailored to ICBM applications. The proposed architecture should show significant advantages in processing speed, processor size and power requirements over conventual architectures. Options for processor architectures and their technological maturity must be assessed.

Phase II: Provide proof of concept along with sizing and power issues as applicable to future vehicle configurations.

D. Micro-Inertial Systems: Micro-machine technology advances have shown the potential for producing arrays of accelerometers and gyroscopes in a 3-axis assembly. These devices may provide inertial guidance in a range of military and civilian systems. Currently, these devices are limited by the precision inherent in the instruments themselves, hence limiting options for their use in long range, unaided strategic systems. Due to the small size of these instruments, several may be packaged in an array. The individual sensor output in the arrays can be statistically combined to

eliminate uncorrelated errors.

Phase I: Identify algorithms and combining techniques to meet this end. Detailed analysis must show the feasibility of these techniques given the micro-instrument production and packaging technology available. Assess potential precision of such configurations.

Phase II: Demonstrate the concepts developed in Phase I through further analysis, development, simulation and prototyping.

AF93-107TITLE: Interference Immune Retrodirective ArrayAF93-107TITLE: Interference Immune Retrodirective Array

CATEGORY: Basic Research

OBJECTIVE: To develop jam-resistant retrodirective antennas for air-to-air/ground communication links.

DESCRIPTION: Covert communications capabilities are needed by special operations forces aircraft to send and receive voice and relative navigation information. Likewise, jam-resistant communications and data links are necessary if navigation information is to be transferred for precision targeting of high value targets. Retrodirective antennas can be important keys for transmitting and receiving in these threatening environments. The advantages of these antennas include higher directive gain, automatic tracking, lower probability of intercept and detection, and jam immunity. This effort would be directed towards the development of airborne and ground based phased arrays with full duplex capability. These arrays could contain 8 to 16 elements and would have the capability to receive and transmit pseudo-noise code waveforms. Undesired signals would be suppressed by up to 30 decibels (Db). Because of the high dynamic environment of the airborne arrays, the cost of adding new aircraft antennas, and the expendability of the ground based arrays, these designs need to track quickly through low cost means. Under Phase I, the contractor shall determine requirements for the retrodirective arrays, and develop candidate designs. For Phase II the contractor shall prove one of the design concepts with a breadboard system that adequately demonstrates the desired performance. The goal of Phase III is to advance the technique sufficiently to support an operational capability.

AF93-108TITLE: Ontogenic Neural Networks for Avionics ApplicationsAF93-108TITLE: Ontogenic Neural Networks for Avionics Applications

CATEGORY: Basic Research

OBJECTIVE: Develop an ontogenic neural network paradigm and define its applicability to a specific avionics problem.

DESCRIPTION: Ontogenic neural networks are those which automatically evolve their structures as they determine their own optimum topology during network synthesis. The genetic ability distinguishes ontogenic neural networks from traditional neural network paradigms which require the user to become an integral part of the learning algorithm. As a result, ontogenic modeling approaches result in true machine learning strategies. There are several avionics applications where the development of a robust ontogenic modeling algorithm may afford substantial benefits. These include, but are not limited to threat response and countermeasure recommendation, pilot aiding, sensor fusion, target identification, and signal processing. During this effort, the benefits of an existing ontogenic neural network paradigm will be demonstrated for a specific avionics problem. The ontogenic paradigm, as a minimum, will have the following characteristics: completely self-organizing without any human intervention; the ability to learn quickly, the ability to represent extremely high order relationships, and the capability to represent conditional relationships at the node travel (i.e., nodal interaction among inputs). In addition, potential areas of algorithm improvement (e.g., increased automation, tailored modeling criteria, global optimization) shall be identified and preliminary algorithm enhancement will be performed. Also, the potential use of modeling heuristics, possibly in the form of a production-rule system integrated with the ontogenic learning algorithm, will be investigated. These areas of algorithm improvement will be

documented as part of the Phase II technical approach. Phase I will identify an existing ontogenic or near-otogenic neural network paradigm which meets the above requirements, develop a feasibility demonstration for a contractor selected avionics problem and perform an initial investigation of the enhancement of the paradigm as described above. Phase II will implement the improvement plan documented during Phase I, and will result in a prototype system suitable for testing in a government avionics laboratory and/or operational environment. The goal of Phase III is to advance the system sufficiently to support an operational capability.

AF93-109TITLE: Avionics Software Design Complexity Measure (ASDCM)AF93-109TITLE: Avionics Software Design Complexity Measure (ASDCM)

CATEGORY: Basic Research

OBJECTIVE: Develop the capability to predict the design complexity of avionics software.

DESCRIPTION: The cost to develop and maintain software is increasing at a rapid rate. Of the total cost to develop the software, the majority of cost is spent in the post-deployment/maintenance phase of the software life cycle. More effort needs to be spent in the earlier phases of the software life cycle in order to produce more maintainable software and to reduce development cost. One measure of software maintainability is the complexity of the software design. The ability to objectively measure the design complexity of the software (which would result in a means of comparing software designs), would be advantageous to the software developer. Currently, metric analysis is performed at the implementation phase on the code itself, if at all. If a change in the design is necessary, the entire design and development effort would be repeated, possibly resulting in endless iterations of design/code redevelopment. This effort will serve to shorten this "iterative" process to the point where the design of the code is what is analyzed, not the resulting software. Additionally, the effort will provide the Air Force benefits in terms of a shorter software development life cycle, a quantitative measure of software design complexity, which in turn will potentially reduce maintenance costs. Work for this effort will be divided into two phases. Phase I will identify what is currently available and applicable to avionics software in terms of design complexity measurement and defining what is not covered by the currently available measures. New techniques will be defined in this phase. In addition, this phase will investigate methods for performing design complexity measurement. Phase II will emphasize the development of a system for automating the process of measuring the design complexity of avionics software. The goal of Phase III is to advance the system sufficiently to support an operational capability.

AF93-110TITLE: Digital Signal Processing for Networked Communications De-interleavingAF93-110TITLE: Digital Signal Processing for Networked Communications De-interleaving

CATEGORY: Basic Research

OBJECTIVE: Develop new signal processing algorithms combined with existing radar processing algorithms to process communications signals.

DESCRIPTION: Modern communications signals are often networked or in a multiple access format to allow several users to occupy a limited bandwidth simultaneously. Possible multiple access formats would include Frequency Division Multiple Access, Time Division Multiple Access and Code Division Multiple Access. Spread spectrum formats such as frequency hopping or direct sequence can be used to perform multiple access. In such a signal environment, which may be corrupted with noise and interference, tracking individual users with limited prior knowledge of their signal is a very difficult task. Several radar processing algorithms have been developed which are used to determine parameters on radar pulses for sorting purposes. These algorithms, combined with developed communications specific algorithms, could be used to track and de-interleave communications signals. Such algorithms would need to process signals based on time-of-arrival (TOAs) and other precision-measured signal parameters which may appear random, staggered, or embedded in other users' signals. Under Phase I, the contractor will examine

existing radar-based algorithms and determine the upgrades/modifications required to process and track communications signals. The contractor will determine other fundamental sorting parameters (such as fine frequency measurement) for the signal formats of interest. At the conclusion of Phase I, the contractor will produce a final report documenting results and conclusions. Under Phase II, the contractor will implement the algorithms into a computer workstation hosted signal processing system, developed from commercial, off-the-shelf equipment. Phase II will result in a system demonstration using live signals plus a final report. The goal of Phase III will be to embed these algorithms into an operational system.

AF93-111TITLE: Reconfigurable, Real-Time Radar Warning Receiver (RWR)AF93-111TITLE: Reconfigurable, Real-Time Radar Warning Receiver (RWR)

CATEGORY: Basic Research

OBJECTIVE: Develop a cost-effective, modular, high-fidelity, reconfigurable, real-time simulation of radar warning receivers (RWR).

DESCRIPTION: A cost-effective method of modeling the full range of radar warning receivers with a high-fidelity, real-time simulation is essential to the efficient development and evaluation of integrated defensive avionics. Past RWR simulations have been designed as clones of individual RWRs and do not operate in real-time. This approach limited their flexibility since it required extensive modifications to model a different RWR and to operate in real time. Usually, real-time operation sacrifices fidelity. This topic area seeks to exploit the technology opportunity presented by recent advances in high-speed digital processors and parallel processing architectures to develop a truly reconfigurable, real-time RWR simulator. A reconfigurable, real-time RWR simulator would make the acquisition process more efficient by providing a cost-effective method for early evaluations of proposed RWR concepts and improvements. The simulator would also provide high-fidelity technology for training and readiness. A successful approach needs to address all aspects of RWR processing functionality: waveform characterization, data correlation, identification, emitter tracking, mode changes, hardware/software architectures, etc. Additionally, the approach needs to address the real-time performance issues associated with the design. Under Phase I, the contractor shall develop a preliminary design with an analysis of feasibility and cost/fidelity trade-offs for the various simulation functions. Performance demonstrations of critical aspects of the design are desired to evaluate risk in proceeding with Phase II. Under Phase II, the contractor shall fabricate, demonstrate, and evaluate the document and the proposed design. Together with the delivery of the system, the contractor shall provide recommendations for further development. The goal of Phase III is to advance the technique sufficiently to support an operational capability.

AF93-112TITLE: High Performance, Economical Frequency SynthesizerAF93-112TITLE: High Performance, Economical Frequency Synthesizer

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate a microwave frequency synthesizer design with improved performance and low cost.

DESCRIPTION: Microwave Radio Frequency (RF) synthesizers are commonly used in modern electronic countermeasure (ECM) systems. Synthesizers using up-conversion offer coherence and low phase noise and spurious products. However, settling time has been 500 nsec to 1 usec. Because mixers are used in the signal path, high-performance microwave filtering is necessary to maintain spectral purity. These designs are inherently complex and thus costly. Direct Digital Synthesis (DDS) has offered a less costly alternative with fast tuning, but spurious content is inherently poor (<50 dBc) and pulse-to-pulse coherence is not offered. Also, both designs provide poor FM range (typically 100 MHz) at the low end of the RF bandwidth. A wideband synthesizer in which the RF is produced without the previous strict reliance on up-conversion or digital synthesis would eliminate the complexity and high cost of up-

conversion schemes, and the poor spectral purity of DDS approaches, yet still provide the fast switching of DDS and the coherence of the up-conversion approaches. Under Phase I, the contractor shall design a digitally controlled synthesizer with the following parameters:

Frequency Range	0.5-20 GHz
Frequency Resolution	<125 kHz
Switching Speed	<300 nsec
Harmonic Spurs	<-60 dBc
Nonharmonic Spurs	<-70 dBc
Phase Noise	<-64 dBc @10 kHz from carrier
	<-100 dBc @1 from carrier
FM Tuning Range	>250 MHz
Amplitude Range	0 to 60 dB
Amplitude Resolution	0.5 dB
Ampl Accuracy vs. Range	+0.5 dB
Ampl Accuracy vs. Freq	<0.6 dB
Service Conditions	+12 to +32 C
Size/Weight	<0.5 ft /<20 lb
	(Power Supply Excluded)
Simulate Multiple Pulse Doppler Signatures with Phase Errors of no greater than 1	
Power Output	0 dBm +3 dB

Phase I shall include a report that synopsizes the effort and estimates production costs compared to available synthesizers, with a goal of 25 to 50% cost savings. Phase II shall provide a brassboard microwave RF synthesizer and acceptance test plan. The Phase II report shall also provide detailed cost and options for production units. The goal of Phase III is to provide synthesizers for a wide range of applications such as, ALQ jammer pods, B-1, EF-111, radar simulators, radar test ranges, shipboard jammers, local oscillators for antiradiation missiles, transmitter exciters for coherent radars, and other commercial applications.

AF93-113TITLE: Superconductor Digital Electronic Warfare (EW) System DevelopmentAF93-113TITLE: Superconductor Digital Electronic Warfare (EW) System Development

CATEGORY: Basic Research

OBJECTIVE: Develop wideband digital superconductor subsystems with adequate performance for EW systems applications.

DESCRIPTION: Superconductivity enables systems to be produced with higher operating frequency, wider bandwidth and lower power dissipation than conventional passive microwave device and digital semiconductor technology. Great success has been achieved in producing low temperature superconductor (LTS) digital components at liquid helium temperatures (4.2 Kelvin); however, liquid helium coolers are impractical for airborne EW system applications. Recent advancements in Rapid Single Flux Quantum technology make digital high temperature superconductor (HTS) technology a real possibility. This effort will explore wide bandwidth digital superconductor concepts supporting EW systems operating over the full 2-20 GHz band. Proposed LTS development will only be acceptable if designs are directly transitionable to HTS technology in the future. One high payoff digital EW application potentially having the broadest application is a wideband digitizer. The digitizer should possess at least 6 effective bits of resolution and 4 to 6 GHz bandwidth. Ultra high speed signal processing subsystems that can process the output of this extremely high speed digitizer will also be required. Signal processors of interest include digital filters, correlators, fast fourier transformers, and single-sideband modulators. Demultiplexers and multiplexers will be needed for interfacing wideband superconductor A/D and D/A components with slower speed semiconductor memory and processors. Under Phase I of the effort, the contractor will develop, or continue development of high payoff components which will support a wideband digital EW system able to operate over 2-20 GHz. The contractor will also produce a final report

documenting results and conclusions. Under Phase II, the contractor will further develop parts of the digital EW system and begin integrating components. A demonstrated system or subsystem will be the goal of Phase II. At the conclusion of Phase II, the contractor will produce and deliver a final report documenting results and conclusions along with a hermetically packaged operational subsystem with input and output connectors. The goal of Phase III is envisioned to develop and integrate more complex system concepts which may include HTS implementation where appropriate.

AF93-114TITLE: Advanced Fire Control/Fusion MethodsAF93-114TITLE: Advanced Fire Control/Fusion Methods

CATEGORY: Basic Research

OBJECTIVE: Develop advanced fire control algorithms for air-to-air and air-to-ground internetted applications.

DESCRIPTION: Recent hardware and software advances in the areas of electronically scanned array radar, multiple target tracking intraflight datalinks, passive sensors, and advanced processors have led to increased weapon system capabilities and tactics not possible before. These advances have also led to increased complexity in handling the information obtained from the application of these new technologies. The use of a datalink to internet aircraft within a flight will significantly change the interaction between those aircraft if fully utilized. The internetting capability enables new passive fire control techniques that could be exploited under this effort. Fusion of data from different sensors and between aircraft will enable multi-ship precision targeting through the reduction of target location errors. Future aircraft will be required to be less specialized and handle a wider variety of missions including both air-to-air and air-to-ground engagements. These aircraft should be able to accept in-flight information from off-board sources that could affect their basic mission parameters. These data may include cues to target positions, intelligence updates on target characteristics, or even changes in primary targets. The algorithms that manage all of these data and the internetted operations of the aircraft should increase reliability and efficiency through the ability to utilize information from other aircraft. For instance, if an aircraft experienced a sensor failure during an operation, the mission could continue if that aircraft was able to utilize targeting information from other aircraft in the flight. Redundancy in sensor coverage and time critical tasks could also be reduced by an adaptive allocation of all resources within a flight. This will increase efficiency, capability, and situational awareness. The objective of this effort is to develop advanced fire control and fusion algorithms that will significantly enhance the capability of aircraft within the internetted environment. Specific areas of interest within internetting include intraflight sensor fusion, and intraflight sensor management. The algorithms developed should be applicable to both air-to-air and air-to-ground engagements. Under Phase I, the contractor shall develop and evaluate approaches to increase the fire control and fusion capability over existing methodologies. The approaches will be evaluated against measures of performance such as performance gain and processing requirements. At the conclusion of Phase I, the contractor shall produce a final report documenting results and conclusions. Under Phase II, the contractor shall implement the selected algorithms and perform detailed evaluations of their performance. The goal of Phase III is to advance the technique sufficiently to support an operational capability.

AF93-115TITLE: Active Expendable Electronic Counter-Countermeasures (ECCM)AF93-115TITLE: Active Expendable Electronic Counter-Countermeasures (ECCM)

CATEGORY: Basic Research

OBJECTIVE: Develop ECCM techniques to counter active expendable electronic countermeasures (ECM)

DESCRIPTION: With the ever increasing number of countries getting into the military equipment sales, the rest-of-the-world (ROW) ECM threat is growing daily. There are many varieties of active expendable ECM threats available for sale to anyone with the money to purchase them. Active expendables are inexpensive radiators that mimic a radar signal. These expendables can also have a reasonable radar cross section (RCS) that resemble the aircraft that has

expended them in an attempt to avoid/break weapon system lock-on. This effort will explore innovative ECCM approaches to counter the active expendable threat. Under Phase I of the proposed research, the contractor will investigate and define new ECCM techniques that will counter the active expendable ECM threat and the potential Terrain Bounce threat. At the end of Phase I, the contractor will be required to produce a final report which documents the investigation and definition of these new ECCM techniques. Under Phase II of the proposed research, the contractor will fully develop and evaluate the technique(s) that showed the greatest potential for success in Phase I. At the conclusion of Phase II, the contractor will produce a final report which documents the technique(s), as well as possible future enhancements. Also, a recommended test demonstration approach for the technique(s) will be presented. The goal of Phase III will be to advance the technique(s) sufficiently to support an operational capability.

AF93-116TITLE: Automatic Target Recognition (ATR) ResearchAF93-116TITLE: Automatic Target Recognition (ATR) Research

CATEGORY: Basic Research

OBJECTIVE: Develop target and background synthetic image capability for high resolution radar and laser radar sensors.

DESCRIPTION: The development of ATR algorithms is dependent on the ability to synthesize and validate target and background signatures. ATR algorithms must be able to efficiently access these signatures to match stored signatures to sensed signatures and must be able to estimate underlying signature parameters such as target pose or target/sensor motion to facilitate the matching process. Both air-to-air and air-to-surface algorithms are of interest using radar, IR, and laser sensors. All Phase I efforts shall result in a proof of concept and a Phase II proposal. At the end of Phase II, the contractor shall demonstrate and deliver the developed technique/capability/tool. The goal of Phase III is to advance the technique sufficiently to support an operational capability. We are seeking solutions to one or more of the following topics:

1) Evaluate model validation metrics to compare high fidelity 1-D, 2-D, and 3-D measured signatures with model predicted high resolution RF target signatures of ground and air targets (model and measurements provided).

2) Develop aircraft radar, radio and navigation antenna (UHF to KU band) models to predict high frequency RF band scattering responses including interaction with aircraft structure (e.g., radomes, antenna covers, exterior, interior, etc.).

3) Develop automated geometry measuring device to measure large objects such as aircraft and ground vehicles for use as input geometry (2-mil accuracy desired) to signature modeling codes. Also desirable to measure surfaces and structures obscured by RF transparent and absorbing materials.

4) Develop data compression techniques to quickly and accurately reproduce signatures using small memory requirements. Offline computation can be traded for on-line efficiency. Low or no loss schemes desired.

5) Develop computer visualization capability to overlay target wireframe on 1-D, 2-D, and 3-D data representations using combinations of angle, angle range dimensions afforded by such sensors as FLIR, laser, and 2-D, and 3-D synthetic aperture radar sensors.

6) Develop total scene simulated imagery capability of FLIR and 3-D laser sensors as sensed from an airborne platform in an air-to-surface tactical target (e.g., tanks) attack scenario. Environmental effects such as fog, dust, and atmospheric turbulence, sensor effects such as sensor pointing jitter, and target/background effects such as target reflectivity variations due to surface roughness and incidence angle should be considered.

7) Develop motion estimation algorithms that estimate sensor motion, independent target motion, and 3-D structure from motion using FLIR imagery.

AF93-117TITLE: Application Specific Electronic Design SynthesisAF93-117TITLE: Application Specific Electronic Design Synthesis

CATEGORY: Basic Research

OBJECTIVE: Develop computer aided design tool which automates the design of related electronics in AF systems.

DESCRIPTION: The Air Force continuously develops complex electronic components and systems for its weapons. These designs utilize many common engineering facets in the areas of functionality and electronic technology. For example, there may be commonality in applications which require data or signal processing or in algorithmic functions, such as filters or transforms. All systems are made up of components such as processors, memories, bus interconnections, and protocols. Systems can also have commonality in electronic technologies used, such as analog or digital and synchronous or asynchronous logic. This topic seeks to develop software tools to perform the automated design, also known as synthesis, of one or more of these common engineering areas. Application areas addressed should be those most relevant to AF systems and the relevancy should be clearly described. It should be shown that the tool to be developed will be easier to use, produce a design significantly more rapid than current methods, handle more complex designs and yield a better optimized design. It should be shown that the technology to be developed does not duplicate current commercial off-the-shelf solutions. Inputs to the tool should be reasonable and natural for the particular design area, i.e., specific to the application and not the implementation. Outputs from the tool should be suitable for design analysis and for direct and immediate progression to the next level of implementation detail.

Phase I: Phase I of this effort will be to do the preliminary design of such a tool.

Phase II: During Phase II the tool will be constructed, evaluated and demonstrated. Reference manuals and user guides will be developed.

Phase III: In Phase III the tool will be integrated into widely used design environments, readied for market and beta tested. Production and support plans will be developed.

AF93-118TITLE: High Temperature Packaging/Interconnect with Metal/Ceramic BondingAF93-118TITLE: High Temperature Packaging/Interconnect with Metal/Ceramic Bonding

CATEGORY: Basic Research

OBJECTIVE: Develop and test methods of bonding metals and ceramics together in high temperature electronic packages.

DESCRIPTION: A number of electronic initiatives have encountered difficulty with their interconnects, bonding and packaging at higher temperatures. Traveling wave tubes have the need to connect SiC or diamond films to copper and other materials for use in heat sinks. In phased arrays and other systems requiring modules, several materials are often bonded and require thermal, electrical, and mechanical continuity. In the case of SiC and diamond semiconductors, the electronic properties of the material still function long after the bonding and interconnects have failed. A series of recent developments show how dissimilar materials may be strongly bonded over a very wide temperature range without compromising thermal
conductivity, electrical continuity, or mechanical integrity. For some using a single step brazing method can fasten dissimilar materials from 0-1000 degrees Celsius, even under the most severe thermal shocks. For large area thermally-cyclic systems, methodologies have been developed to minimize stresses for the best possible bonding. Much of the work in this area has already been demonstrated for the materials of interest, but little has been done to apply it to specific systems. It is mainly a question of identifying where problems presently exist and determining if these new bonding methods can be applied.

Phase I: In Phase I emphasis will be placed on identifying which type of packaging and interconnect problems exist presently which can be remedied by the new bonding methods.

Phase II: Phase II will focus on demonstrations of improved bonding and interconnects for a variety of targeted problem areas.

Phase III: In Phase III the contractor should develop new and unique packaging designs and methodologies taking advantage of the new materials and bonding techniques. The program deliverables will be a technical report outlining the new bonding methods, where these bonding methods may be applied and the results of applying these new methods to specific needs.

AF93-119TITLE: Automated Defect Analysis Using Image Processing TechniquesAF93-119TITLE: Automated Defect Analysis Using Image Processing Techniques

CATEGORY: Basic Research

OBJECTIVE: Produce prototype system which performs highly automated quantitative defect analysis of processed/unprocessed semiconductor materials.

DESCRIPTION: Automated defect analysis is needed for semiconductor and other materials both in R&D and manufacturing technology. Limited automation exists for quantitative analysis of the sizes, shapes, orientations, distributions, and numbers of surface defects, such as etch pits and oval defects, which can occur in densities from 1 to 10 to the 6 power defects/cm squared. This type of work is typically performed manually with microscopes or photomicrographs. Current image processing techniques have the capability to perform some quantitative analysis, although further development may be required. The benefit of such capabilities would be the improvement of defect metrology in the R&D community, improved materials qualification techniques for vendors and users, and spin-off technology in image processing instrumentation and techniques.

Phase I: Phase I is envisioned as a feasibility effort to determine the capabilities of image processing techniques to quantify size, shape, and distribution of defects; to design a modular system consisting of image acquisition, image processing and sample positioning and registration; and to address instrument limitations, such as resolution and contrast.

Phase II: Phase II would involve the construction and demonstration of a device capable of quantitative defect analysis across entire sample surfaces thereby providing a high speed, high quality testing capability.

Phase III: Phase III will consist of final development and test of a commercial product.

AF93-120TITLE: Machine Thinning of Gallium Arsenide (GaAs) WafersAF93-120TITLE: Machine Thinning of Gallium Arsenide (GaAs) Wafers

CATEGORY: Basic Research

OBJECTIVE: Develop and refine precision surface machining technology and apply it to GaAs wafer thinning

DESCRIPTION: This program will assess the cost and/or RF performance advantages of GaAs wafer thinning by one-pass machine cutting as compared to GaAs substrate backside lapping and polishing as is presently practiced in industry. The scope of the program includes effort in the refinement of diamond turning machinery to achieve GaAs wafer thickness, surface flatness, and parallelism exceeding the quality of present lapping and polishing practices.

Phase I: Phase I of this effort will include implementation of necessary modifications and refinements to present surface cutting machinery in order to achieve wafer thickness control, flatness uniformity and throughput exceeding present GaAs substrate backside thinning methods. Phase I will also include the investigation and characterization of machine thinned, bare GaAs substrate acquired as experimental samples. Full physical, and electronic characterization (e.g., surface roughness, subsurface damage, changes in mobility, etc.) of the thinned GaAs substrates to assess damage or degradation will be required.

Phase II: During Phase II, after completing all necessary machine refinements, the contractor shall machine-thin representative GFE processed and tested wafers. The objective of this exercise will be to compare the DC and microwave RF performance of these machined wafers to sets of control wafers that were backside processed by standard methods. The contractor must consider any special care or handling of these thinned wafers and any additional treatment, such as touch-up etching that might be required before further processing. The contractor shall consider automation, manufacturing yield, and unit cost as major factors in this development effort with the objective of replacing wafer thinning by lapping and polishing with more accurate and less expensive methods.

Phase III: Phase III shall consist of implementation in a production environment and assessment of final yield and

cost data.

AF93-121TITLE: Gallium Nitride (GaN) Device DevelopmentAF93-121TITLE: Gallium Nitride (GaN) Device Development

CATEGORY: Basic Research

OBJECTIVE: Develop detectors, active waveguides, lasers, and/or optoelectronic components based on gallium nitride III-V materials.

DESCRIPTION: III-V gallium nitride has several potential advantages over other semiconductor material systems. The material has matured to the point where the material properties may be exploited in detectors, active waveguides (switches and modulators), lasers and/or optoelectronic components including cellular arrays. The Air Force has applications for ultraviolet detectors and lasers, multiwave mixing devices, optical interconnects, and blue lasers. Integration with other III-V compounds, like gallium arsenide is feasible. The prospective contractor should draw on existing III-V material technology in proposing a device or devices which offer an opportunity to use the unique properties of gallium nitride.

Phase I: Phase I should establish the feasibility of the proposed device and should, at a minimum, demonstrate a basic device structure.

Phase II: Phase II would produce an optimized device or devices and establish processing and fabrication techniques for the device or devices.

Phase III: Phase III will develop a production prototype of the device or devices and demonstrate integration into active waveguides.

AF93-122TITLE: Particle MicrosensorsAF93-122TITLE: Particle Microsensors

CATEGORY: Basic Research

OBJECTIVE: Develop new and innovative in situ particle microsensor devices for semiconductor manufacturing.

DESCRIPTION: Semiconductor device fabrication facilities are increasingly dependent on real-time sensors and process controls for first-pass success in the fabrication of complex semiconductor devices and integrated circuits in small quantities. The trend in advanced device manufacturing is moving toward single-wafer processing using all dry plasma processes for deposition, etching, etc. As more complex devices and processes are developed, real-time sensors and process control become even more critical. In many cases special sensors are needed, since these devices must frequently operate in a plasma or a reactive-gaseous environment at elevated temperatures. Real-time, in situ sensors for the measurement of 0.1 - 10 micrometer particles generated during plasma processing are a critical problem area. Conventional optical scatterometer techniques for measuring particle densities in a flowing gas stream are no longer adequate. Techniques of counting particles on wafers during postprocessing microscopic inspections are also not adequate. In situ microsensor devices using new approaches and/or phenomena to detect particles on a wafer in the above environments are urgently needed.

Phase I: Phase I will consist of a 6-month feasibility investigation to design a new microsensor particle detector device. It is highly desirable that this device be capable of being integrated with digital signal processing devices on a single semiconductor chip. Proposed device designs should be theoretically analyzed to determine the technical feasibility of the design approach including sensitivity, range of detection, linearity, ease of fabrication, cost, and applicability to the above problem. Preliminary laboratory measurements to demonstrate technical feasibility of the approach should be performed and discussed in the final report.

Phase II: Phase II of this effort will consist of 24 months of additional work to perform detailed device design, fabrication, and demonstration. Measurements should be made to determine the limits of performance, operating parameters, and benefits of this design over competitive approaches.

Phase III: Phase III will develop a production prototype of the device and demonstrate the device in actual semiconductor production equipment.

AF93-123TITLE: Flight Control Science and TechnologyAF93-123TITLE: Flight Control Science and Technology

CATEGORY: Basic Research

OBJECTIVE: Develop flight control science and technology to support air power projection and/or Precision Strike.

DESCRIPTION: Develop one or more of the following advanced flight control technologies for future aircraft: a) control effectors (moment generators) that reduce or eliminate the need for conventional control surfaces, b) design criteria for new generation pilot displays and landing aids that account for the effect of visual cues on aircraft flying qualities, c) devices that facilitate extended maneuvering envelope stability and control testing in existing Air Force aerodynamic research facilities such as the Wright Laboratory's Vertical Wind Tunnel, d) control system configurations for nonlinear and time varying flight conditions, e) neural network and/or fuzzy logic based adaptive control, f) analytically derived designs for rate, attitude, and position control laws, g) computationally efficient flight management algorithms for real-time all weather guidance of combat aircraft, h) on-board system diagnostics concepts for highly integrated vehicle management systems, i) real-time, high-fidelity multisensor image fusion software for piloted vehicle control, j) non-obtrusive air data measurement for high-speed vehicles, k) structural response feedback techniques for flight control, l) aerodynamic, structural and propulsion data measurement for hypersonic vehicle control.

AF93-124TITLE: Innovative Low-Cost, Lightweight Structural ConceptsAF93-124TITLE: Innovative Low-Cost, Lightweight Structural Concepts

CATEGORY: Basic Research

OBJECTIVE: Utilize advanced materials, manufacturing and design techniques to develop innovative, low-cost, lightweight structural airframe concepts.

DESCRIPTION: Over the past several years, significant advances have been made in the areas of engineered materials (e.g., composites), net or near-net shape manufacturing methods, and design concepts. Of these areas, engineered materials, which are designed to have specific characteristics, may possess the most far reaching potential for achievement of revolutionary advancement in structures technology. Exploitation of this potential is required to achieve long term goals of 50% airframe weight reduction and 50% cost reduction in future Air Force aircraft. Innovative structural airframe concepts for service temperatures less than 700oF, which focus on an engineered materials approach in conjunction with low-cost manufacturing methods, are required. Areas of ultralightweight/low-cost metallic and composite structural concepts and joining methods, highly robust composite structures for severe service usage having improved durability and impact resistance, and multifunctional smartskin structures approaches which incorporate embedded electronics for sensing or communications to achieve overall system weight savings. Concepts are required for both lightly loaded and heavily loaded airframe structural applications, covering vehicle classes from future fighters and High Altitude Long Endurance type platforms to retrofits on existing cargo and bomber aircraft. In the Phase I proposal, bidders should demonstrate a clear understanding and familiarity with the technical issues and should clearly explain the uniqueness of their approach.

Phase I: Will establish the technical feasibility of candidate innovative, low-cost, lightweight structural airframe concepts. Limited, small specimen mechanical testing should be performed to aid in assessing feasibility.

Phase II: Will scale up the approach to larger structural sections, generate mechanical property data, and perform testing to verify structural integrity under anticipated service conditions.

Phase III: Commercialization will exploit the structural developments achieved during Phase II for high payoff applications to all classes of military aircraft and advanced commercial and private aircraft.

AF93-125TITLE: Fighter Cockpit Precision Cursor ControlAF93-125TITLE: Fighter Cockpit Precision Cursor Control

CATEGORY: Basic Research

OBJECTIVE: Design and evaluate precise and rapid methods for cursor control in fighter cockpits.

DESCRIPTION: Future high definition cockpit displays have the potential of presenting more information in a given size of display space than in current cockpits. As a result, if a pilot is to provide control through a cursor on the screen, precise, as well as rapid positioning of the cursor in an information dense picture will be mandatory. Single pilot operation and limited cockpit space in a fighter make the problem of designing a control device more difficult than in a multicrew transport or bomber. The current method of controlling a cursor in a fighter cockpit using a pressure sensitive rate switch mounted on a throttle is inadequate. Rate (first-order) controllers require more time and attention to move to any desired position, and can be frustrating to place precisely compared to position (zero-order) controllers. The objective of this effort is to develop alternate control schemes and devices, and evaluate them in piloted simulation of fighter combat operations.

Phase I: Will include mission analysis, preliminary designs, and selection of concepts for Phase II development.

Phase II: Will include hardware and Ada software code development, and piloted simulation evaluations of the selected concepts.

Phase III: The integration of a concept into flight qualified hardware and software.

AF93-126TITLE: Dynamics Displacement and Strain Measurements for Aircraft TiresAF93-126TITLE: Dynamics Displacement and Strain Measurements for Aircraft Tires

CATEGORY: Basic Research

OBJECTIVE: Develop equipment to measure aircraft tire surface strains and displacements during dynamometer tests.

DESCRIPTION: The Air Force need for "Extended Life/Reliable Tires" will be addressed by extending testing capabilities to include measuring tire surface strains and displacements during dynamometer testing. This capability will allow strain and displacement comparisons to be made between manufacturers, construction type, and operating conditions. There is no efficient way of measuring and quantifying tire strains and displacements during static and dynamic conditions. This capability is a significant technology breakthrough for designing and evaluating extended life tires which will enable the Air Force to achieve its goal of doubling current aircraft tire life. Annual Air Force savings if this goal is achieved is projected as $9 million per year for the F-16 fleet.

Phase I: Will determine the applicability of such equipment using (Shadow Mooire, Shearographic, Holographic or Other) methods. The necessary requirements include that the system must not impede normal dynamometer operations, the system is desired to be remote (at least 10 ft from the dynamometer) and the dynamometer be 120 inches in diameter with a maximum tire rotational speed 80 Hz. The system should contain capabilities to store the test data to play back strain histories during the dynamometer test cycle. The system should allow graphical display of the tire with line contours and calibrated digitized data. Desired data to be extracted are the normal and tangential displacements and the three components of in plane strain. The system should allow a variable sensitivity level to analyze both high and low deflection conditions.

Phase II: Will require the contractor to manufacture the equipment and install the system on the Wright Laboratory's 120 inches south carriage dynamometer. Validation tests will be performed using static, high speed, cornering and braking conditions using a preselected Air Force Tire.

Phase III: Validated high-speed dynamic displacement/strain measurement systems could then be marketed by the small business to the tire industry.

AF93-127TITLE: High Frequency Hypersonic Fluid DiagnosticsAF93-127TITLE: High Frequency Hypersonic Fluid Diagnostics

CATEGORY: Basic Research

OBJECTIVE: Develop innovative system to measure time-resolved thermodynamic or velocity fluctuations in hypersonic wind-tunnel flow.

DESCRIPTION: Time-histories of fluid fluctuations are required to understand the physics of turbulent or unsteady flows. Due to the high velocities and small dimensions of hypersonic wind tunnel shear flows, fluctuation frequencies reach several hundred kilohertz or even the megahertz range. The high frequencies and high temperatures associated with hypersonic flow place an extreme burden on measuring systems. The only systems currently used to measure hypersonic fluid fluctuations are constant-current hot wire anemometers, which suffer a number of drawbacks. The hot wires must be small in size to reduce their thermal capacitance and must be heated above wind tunnel stagnation temperatures. These factors make the probes extremely fragile and difficult to handle. Calibration and interpretation of the signal is difficult, and the probe output must be frequency compensated to correct for its finite thermal inertia. Optical diagnostics which rely on scattering from seed particles or air molecules are non-intrusive, but current systems are incapable of measuring at useful frequencies due to low photon capture rates. Some systems permit essentially instantaneous measurements, but the measurement repetition is too slow to obtain spectral resolution in frequency range of interest. An innovative measurement system is sought which would allow measurements at frequencies up to 1 megahertz, at Mach numbers up to 14, and at dynamic pressures up to 6 psi. The system may be intrusive or non-intrusive, and the output should be reducible to thermodynamic properties or velocity.

Phase I: Will analyze the proposed system and demonstrate its feasibility.

Phase II: The system will be installed and demonstrated at Wright Laboratory.

Phase III: The technology developed in the first two phases will be developed by the small business for marketing to the entire aerospace industry.

AF93-128TITLE: Mission and Flight Control SimulationAF93-128TITLE: Mission and Flight Control Simulation

CATEGORY: Basic Research

OBJECTIVE: Development of improved simulation methods for engineering development supports precision strike and air power projection.

DESCRIPTION: Develop one or more innovative methods for software or hardware that will create new or improve existing capabilities or reduce acquisition and maintenance costs for a) secure, long haul (many miles) simulation networks, including methods for reducing time delays and reducing long haul traffic without exceeding the maximum allowable delays for piloted simulations; b) flight simulator displays where the special interest areas are improving the brightness, contrast, resolution, field of view, and reducing geometric distortion as seen by the pilot, reducing the weight and improving the center of gravity for helmet mounted displays, development of multiple eye point display technologies, and multiline rate compatible displays; c) adding or improving dynamic distortion corrections for simulator displays that improve performance or reduce latency or costs; d) automated simulation threats or digital simulation players for force level simulations that can improve fidelity, improve tactics, increase the number, reduce setup complexity or reduce latency of computer generated models.

AF93-129TITLE: Thermal Energy Recovery and ManagementAF93-129TITLE: Thermal Energy Recovery and Management

CATEGORY: Basic Research

OBJECTIVE: Identify viable methods of recovering and utilizing wasted thermal energy generated by aircraft systems.

DESCRIPTION: All aircraft systems generate waste heat. Currently, this heat is dissipated without gaining any particular benefit. Ever decreasing DOD budgets demand that Air Force systems become more affordable. One possible way of achieving this goal is by the recycling of wasted thermal energy presently generated throughout our aircraft systems. We are interested in innovative methods of recovering and utilizing this energy to produce useful work. Emphasis should be on fighter type aircraft, but technology that is applicable to other aircraft types is desirable. The research should examine all available heat sources with regard to collection, recovery, and conversion into a useable energy source. Specific applications that could be powered by the recycled thermal energy may be considered, as well as the task of simply producing alternative energy sources such as electricity.

Phase I: Energy recycling concepts will be developed and conversion feasibility will be demonstrated.

Phase II: Build and demonstrate the performance of those concepts developed during Phase I.

Phase III: Validate a full scale energy recycling system.

AF93-130TITLE: Active Flow Control Device DevelopmentAF93-130TITLE: Active Flow Control Device Development

CATEGORY: Basic Research

OBJECTIVE: Improve the performance of military aircraft through the practical application of active flow control devices.

DESCRIPTION: Military aircraft of various types experience performance limitations due to encountering regions of separated flow at various flight conditions. These regions of detached flow can be precipitated by elevated aircraft angle-of-attack (wing stall), open cavities (weapon bays), nonaerodynamic shaped appendages (electronic countermeasure pods) and other means. Static flow control devices such as wing leading edge flaps and vortex generators have been used successfully to reduce regions of separated flow and increase aircraft performance in specific flight regimes. The development and application of practical active flow control devices offer the potential for far greater separated flow control over a wider range of flight conditions.

Phase I: Will include an experimental demonstration of an active flow control device that will improve military aircraft performance by controlling the aircraft flowfield in a practical way.

Phase II: Will include an active flow control device performance validation ground experiment under simulated flight airflow conditions.

Phase III: Shall flight demonstrate the active flow control device at full scale

AF93-131TITLE: Facilitating Accident Evaluations of Aircraft with "Glass" CockpitsAF93-131TITLE: Facilitating Accident Evaluations of Aircraft with "Glass" Cockpits

CATEGORY: Basic Research

OBJECTIVE: Develop means for determining what the cockpit primary electronic displays were portraying immediately prior to accident.

DESCRIPTION: Despite the availability of crash data recorders and cockpit voice recorders, official investigations of aircraft accidents often also involve the examination of primary cockpit instruments. Heretofore, such instruments were of mechanical design. As such, they could offer positive clues of what the instruments were reading at the time of crash. . . that is, the position of jammed gears, heat imprints of dial indicators, etc. Future military cockpit instruments will be of electronic design (Cathode Ray Tubes, Flat Panel Displays, etc.) and will not be capable of providing accident investigators with such "a look" at what the pilot saw immediately prior to crash. A technique is now needed that will enable investigators to continue evaluating instrument readouts, as they appeared to the pilot, immediately

prior to the accident. . .at least, to the extent that was possible with the past generation of mechanical instruments. Such "looks" need not replicate all the detail or resolution shown on the primary electronic display instruments. Only that detail need be provided which will enable positive identification of the usefulness of the display instrument, and, positive identification as to the subject matter being portrayed. . .just prior to the accident. Such methods should obviously be able to resist the extreme environments (heat, shock, moisture, etc.) associated with crashes. Also, such techniques should have negligible or no negative impact on the reliability of the cockpit instruments. Small physical size, simplicity, and economical production should guide the design concept. The use of special ground support equipment, in conjunction with the newly developed airborne "devices," is an accepted fact. The concept being sought should not be based on use of the classical video camera.

Phase I: Will define and validate the concept via analytical methods. some validation via simple lab demonstrations is also desired.

Phase II: Will apply the acquired Phase I principles to actual hardware transition to a potential production prototype.

Phase III: Will deal with those fabrication aspects that focus on producibility of the associated hardware.

AF93-132TITLE: Carbon-Carbon for Space StructuresAF93-132TITLE: Carbon-Carbon for Space Structures

CATEGORY: Exploratory Development

OBJECTIVE: Enhance state-of-the-art space carbon-carbon by lowering minimum gauge, improving test, and bonding methods.

DESCRIPTION: Future spacecraft will require advanced materials to save weight and maximize performance. Carbon-Carbon has extremely high specific properties, doesn't outgass, and is survivable (laser, nuclear). In order to be a viable material of choice for space, the state of the art must be advanced in the following areas: (a) Minimum Gauge. In order to minimize weight of the component, thin ply carbon-carbon is needed. Current state of the art is around 20 to 30 mils in the composite with ply thickness of 7 to 10 mils. Applications exist for multi-ply composites under 10 mils. (b) Test Methods. Thin walled (10 to 100 mil), high modulus (greater than 40Msi), complex shape composites present a unique testing challenge. Innovative test methodology is needed to enhance property determination. (c) Bonding Methods. For space structures, weight in the joint is in many cases the dominant portion of the structure weight. Improved carbonaceous bonding or brazing may decrease weight over that of a bolted design for either thermal or mechanical joints. (d) Laser Effects. The minimum heat treatment cycle needs to be determined for the range of carbon-carbon matrices in order to establish the most economical cycle that does not outgass under threat conditions. (e) Environmental Effects. Parametric studies need to be performed to determine how thin a coating must be (on a variety of different weave constructions and deposition techniques) to provide an effective barrier to atomic oxygen. Phase I will consist of parametric studies and model behavior with small coupon level articles produced and evaluated. For Phase II, R&D will continue for the most promising Phase I concepts. Phase III would further develop materials and processing capabilities such that a successful transition is made to industry through concurrent engineering between disciplines (designers, thermal and mechanical analytic modeling, materials manufacturers).

AF93-133TITLE: Advanced Thermal Protection MaterialsAF93-133TITLE: Advanced Thermal Protection Materials

CATEGORY: Exploratory Development

OBJECTIVE: Investigate advanced thermal protection materials and associate technology.

DESCRIPTION: Advanced thermal protection materials are required for future ballistic and maneuvering reentry vehicle systems. Projected maneuvering reentry environmental trends, for example, include extended heating, heat soak-out effects, large structural loads, and terminal targeting. Phase I will investigate advanced materials and associate technology including innovative materials concepts, analytical/experimental techniques to assist in materials selection

and potential performance assessment, and mechanistic studies on critical material/environmental interactions. Reentry vehicle components and elements include the nosetip, heatshield, leading edges, antenna window, control surfaces, interface joints, thermal insulation, structure, specialized surface treatments, boundary-layer, and trailing wakes. Phase I studies within this broad technical field must address key technical challenges for significant improvements over the current state of the art. Prior art (circa 1958 onward) will be considered in determining potential performance payoff or possible duplication of effort. Phase II will continue the R&D of promising materials and technological elements, with emphasis upon understanding the interrelationships between materials compositional variables and thermal protection performance. Phase III would develop a materials and processing capability for processing high performance materials for flight test (or equivalent ground test) demonstration. (This topic does not address compiled materials property/performance databases, film/transpirational cooling, manned reentry vehicle systems, refractory ceramic composites, or reusable thermal protection materials.)

AF93-134TITLE: New High Performance Polymers for Opto-ElectronicsAF93-134TITLE: New High Performance Polymers for Opto-Electronics

CATEGORY: Exploratory Development

OBJECTIVE: Investigations are sought to discover new polymeric materials with potential for the development of improved opto-electronic materials.

DESCRIPTION: Investigate the synthesis, theory, processing, and properties of new polymers to provide performance advantages over state-of-the-art materials. Polymer systems with exceptionally high nonlinear optical coefficients, optical transparency, or intrinsic conductivity and reasonably low processing requirements are of primary interest. Areas of emphasis include investigations of (a) theoretical and synthetic chemistry to provide fundamental understanding of the molecular requirements for achieving nonlinear optical or intrinsically conductive properties and optical transparency in organic and semiorganic polymer systems, (b) processing and morphology of polymers to discover approaches for achieving superior nonlinear optical coefficients, intrinsic conductivity, and optical transparency, (c) polymer structure-property correlations to elucidate processing options for achieving desired morphologies as well as opto-electronic, optical, and electrical properties, (d) novel composite materials or material configurations to advantageously use multifunctional properties of polymers such as photoconductivity, photorefraction, light emission and light detection. The establishment of viable approaches to obtaining improved nonmetallic materials are sought in Phase I efforts which can be pursued in Phase II follow-on efforts to screen and further develop the new high performance polymers to optimize their opto-electronic properties and processability. Phase III would determine the data necessary to successfully transition this technology to industry including factors of scale-up, cost, and devise applications.

AF93-135TITLE: Optical Signature Control MaterialsAF93-135TITLE: Optical Signature Control Materials

CATEGORY: Exploratory Development

OBJECTIVE: Develop new and improved materials for controlling the optical signatures of aircraft.

DESCRIPTION: The Air Force is interested in conducting research into the science of understanding and controlling the optical signature of aircraft with emphasis on the infrared region. Specifically, research shall involve controlling emissivity/reflectivity in the ultraviolet, visible, and infrared regions of the electromagnetic spectrum. Investigations may include bulk materials properties and/or novel concepts based on combinations of constituent materials in some unique construction. Phase I will address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II will further develop and optimize the material(s) techniques, and produce larger samples for a full spectrum of evaluations. Phase III would scale up the production capability and produce the material in sufficient quantities to be used on military aircraft.

AF93-136TITLE: Advanced Aerospace Metallic CompositesAF93-136TITLE: Advanced Aerospace Metallic Composites

CATEGORY: Exploratory Development

OBJECTIVE: Develop improved metallic composites based on alloys of Aluminum, Titanium, or ordered intermetallic compounds.

DESCRIPTION: Unique approaches to the development and processing of advanced metallic composites are needed to achieve the goals of major Air Force initiatives such as National Aero-Space Plane and Integrated High Performance Turbine Engine Technology. Composites based on alloys of Titanium, ordered aluminide compounds, and other intermetallic compounds provide significant potential for increased operating temperatures and decreased density. Novel approaches utilizing continuous and/or discontinuous reinforcements in a continuous matrix are of interest, as well as more recent approaches, including ductile phase toughening, intermetallic eutectic alloys, and laminated composites. Novel concepts for composite processing leading to improved compositional, microstructural, and interface control (such as vapor processing) are sought. The basis for anticipated benefits must be clearly established prior to Phase I activity. Phase I of the program must address materials requirements and goals for relevant aerospace applications, and develop proof of concept through mechanical property determinations or other relevant tests.

Phase II will optimize chemistry, processing, and microstructure, and produce larger amounts of material for a full spectrum of mechanical property evaluation. Phase II will also include a preliminary evaluation of trade and design studies to give an early indication of future application potential. Phase III would pursue composite development activities aimed at specific aerospace components.

AF93-137TITLE: High-Temperature Structural Materials for Advanced Air Force SystemsAF93-137TITLE: High-Temperature Structural Materials for Advanced Air Force Systems

CATEGORY: Exploratory Development

OBJECTIVE: Develop and characterize advanced high temperature structural materials

DESCRIPTION: New approaches are requested to develop and characterize (a) advanced high temperature structural ceramic composites (2500F to 4000F, excluding carbon-carbon composites), (b) intermetallic materials and composites (2000F to 3000F, excluding nickel aluminides and titanium aluminides), and (c) model forming process for advanced structural materials. For ceramic composites, research is limited to continuous ceramic fiber reinforced ceramic matrix systems and may include the following: (a) new, unique ceramic composite development; (b) fiber/matrix interface treatments engineered for toughened behavior and stability; (c) continuous ceramic fiber development; (d) test techniques to determine mechanical and physical behavior (such as failure modes, crack and void growth, oxidation, stress-strain, cyclic stress-strain etc.) as a function of temperature and loading history; and (e) analytical modeling of composite behavior. For intermetallic materials, research is limited to (a) new or novel methods for synthesis and processing of composites from intermetallic alloys which emphasize achieving theoretical density, low defect and interstitial content, and low synthesis temperatures; (b) methods for modeling intermetallics and intermetallic composites which lend insight into chemistry selection and control as well as microstructural selection and control (c) methods of fabricating composites to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale; and (d) methods for environmental protection of intermetallic composites aimed at providing long life under cyclic oxidation conditions. For modeling of forming processes, research may include modeling of (a) the unit forming process, (b) the material behavior in response to the demands of the unit process, (c) the interface between the work piece and the die of mold, and (d) novel methods for obtaining physical property data and constitutive equations for insertion into models. Phase I will focus on the critical issues which, when solved, will provide proof of concept. Phase II will be structured to develop and refine those

feasible concepts to the point where an assessment could be made of the ultimate potential to help meet Air Force advanced materials needs. Phase III would pursue material development effort aimed at specific aerospace components.

AF93-138TITLE: Improved Nondestructive EvaluationAF93-138TITLE: Improved Nondestructive Evaluation

CATEGORY: Exploratory Development

OBJECTIVE: Development of new, nondestructive, evaluation techniques for advanced aerospace applications.

DESCRIPTION: Advanced, innovative approaches are needed for the development of new and improved nondestructive inspection and evaluation techniques for the detection, imaging and characterization of flaws and other integrity-reducing anomalies in flight vehicle and engine materials including metals, and metal and non metal matrix composites. Improved techniques are also needed for real-time monitoring of the manufacturing processes used to fabricate aerospace components from these materials. In particular, innovative technical approaches are needed for (a) the detection, imaging and characterization of bulk and surface anomalies both metallic and nonmetallic structures, (b) the evaluation of the integrity of bondliness in structures containing adhesive and metal-metal bonds, (c) the determination of the condition of matrix and reinforcing substructures in advanced composite structures, (d) establishing the quality of high-temperature material coatings, (e) the inspection and evaluation of electronic device materials and components, (f) the quantitative characterization of materials properties, and (g) detection and characterization of corrosion in hidden/nonaccessible locations before significant material loss has occurred. Technical approaches proposed must either achieve clearly significant
improvements in the standard techniques currently being used in factory and field inspections, or must identify new inspection and evaluation technologies which have capabilities far superior to those currently used and which have the clear potential for ultimate use in realistic manufacturing or in-service environments. Phase I of this program would address the initial formulation, fabrication, and evaluation of specific NDE techniques for demonstration of proof of concept. Phase II will perform enhanced development for optimization of the techniques investigated in Phase I. Phase III would, as appropriate, perform the remaining development required to bring the technique or equipment of a marketable state.

AF93-139TITLE: Biotechnology for Nanostructures, Electronic, and Optical ApplicationsAF93-139TITLE: Biotechnology for Nanostructures, Electronic, and Optical Applications

CATEGORY: Exploratory Development

OBJECTIVE: Apply biotechnology to obtain novel processes or materials to solve AF problems.

DESCRIPTION: The Air Force is interested in research and development projects directed toward potential applications of biotechnology to aerospace requirements. Such programs should address the fabrication of materials with compositions and/or microstructural morphologies of such complexity that they are only obtainable through natural processes. The study of this area could conceivably lead to the development of lower energy processing and materials with very specific electronic and electro-optical properties and contain very few microstructural anomalies. Since biological materials often perform several functions with ease, an investigation of the trade-offs involved in natural material systems could lead to a design philosophy for multifunctional materials with, for example, both electro-optical and structural properties. In a Phase I, programs in these areas should address the requirements and goals of the proposed efforts, as well as initial formulation, fabrication, and evaluation required for proof of concept. In Phase II, the process or design concepts from Phase I would be developed through optimization and scale-up efforts to establish feasibility for manufacture. Either process or design concepts would lead to a marketable product after a Phase III program.

AF93-140TITLE: Nonlinear Optical MaterialsAF93-140TITLE: Nonlinear Optical Materials

CATEGORY: Exploratory Development

OBJECTIVE: Develop nonlinear optical materials with superior properties as compared to those presently available.

DESCRIPTION: Nonlinear optical materials are required for a variety of potential Air Force applications including optical signal processing (switches, modulators, and guided wave devices) and new laser sources (optical parametric oscillators and harmonic generators). However, presently available materials are unsatisfactory for many applications due to small nonlinearities, poor optical clarity, long response times, difficulty in processing for devices, and other factors. Proposed efforts must address material issues for either inorganic or organic materials in either bulk or thin film forms. Innovative techniques for preparing new materials are encouraged. Nonlinear optical devices may be examined only for the purpose of evaluating and demonstrating the properties of the material(s) as a minor part of a materials effort. Phase I of this program will demonstrate the proposed growth or processing techniques. Phase II will develop advanced nonlinear materials and relevant processes to demonstrate potential. In Phase III, advanced nonlinear optical materials would be optimized for specific applications.

AF93-141TITLE: Advanced Semiconducting MaterialsAF93-141TITLE: Advanced Semiconducting Materials

CATEGORY: Exploratory Development

OBJECTIVE: Develop advanced wide band gap semiconducting materials and improved processes for the growth of these materials.

DESCRIPTION: Advanced Air Force systems will require new and novel semiconducting materials to meet challenging power, frequency, speed, and temperature requirements. Conventional semiconductors such as bulk silicon and gallium arsenide cannot meet these requirements. Materials systems of interest are silicon carbide and III-V nitrides. Both bulk and epitaxial material are of interest, as well as heterostructures and superlattices, as well as alloys or heterostructures of III-V's with group IV elements, compounds and alloys. Growth of these new materials requires the development of improved techniques for epitaxial and bulk growth. The offeror is reminded that this is a materials task and projects that are primarily device development or device processing will be considered nonresponsive. Phase I will address process development and initial testing to show proof of concept. Phase II will develop the advanced semiconducting material or process to demonstrate the potential application. Modeling studies of the growth process or materials properties are appropriate for Phase I or as a part of Phase II. Deliverables of test materials to the government for testing are encouraged. In Phase III the advanced semiconducting material or process would be optimized for specific applications.

AF93-142TITLE: High Temperature Superconducting MaterialsAF93-142TITLE: High Temperature Superconducting Materials

CATEGORY: Exploratory Development

OBJECTIVE: Develop processes for fabricating high temperature superconducting thin film junctions for electronic and opto-electronic applications.

DESCRIPTION: High temperature superconducting (HTS) materials offer a variety of application opportunities. For example, detection of infrared (IR) radiation can potentially be improved by increasing sensitivity, operating temperature, and signal processing speed over present technology. The properties of the materials and interfaces must be controlled, and detection techniques must be evaluated in order to fully assess the value of HTS technology.

Development of unique thin film deposition and processing methods for fabrication of junctions or hybridization with other electronic technologies, investigation of the superconducting/nonsuperconducting material interface, and measurement of the opto-electronic response of films and junctions are examples of subjects considered appropriate for this program area. This topic addresses the development of thin film processing techniques, particularly for fabrication of SNS and possibly SIS junctions, and the characterization of opto-electronic properties. Device development will not be supported. Phase I will address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II will perform enhanced development for optimization. In Phase III, HTS materials would be optimized for specific applications such as infrared detection and digital processing.

AF93-143TITLE: Biodegradable Plastic Media Blast (PMB) MaterialsAF93-143TITLE: Biodegradable Plastic Media Blast (PMB) Materials

CATEGORY: Exploratory Development

OBJECTIVE: Demonstrate feasibility of biodegradable abrasive media for use in stripping paint from aircraft structures/components.

DESCRIPTION: State-of-the-art PMB materials are either conventional thermoset or thermoplastic materials and are not easy to dispose of after use. Biodegradable plastic media needs to be developed that can be utilized in conventional PMB equipment, resulting in removal rates equal to the conventional PMB materials. This new biodegradable PMB material should be easily and rapidly digested or degraded by biotechnology processes to environmentally acceptable waste stream products. Phase I goal is to demonstrate feasibility of development of readily biodegradable plastic abrasive media that affords strip rates competitive with those materials currently in use. Phase II is to optimize material for degradability and strip rate. Evaluate effects on substrate mechanical properties and repaintability. Set up tests to determine equipment operating parameters. A full-scale demo on operational equipment and on operational aircraft - establish M&P specifications and finalize on process controls and parameter setting would be the goal for the Phase III effort.

AF93-144TITLE: Sol-Gel Deposition of Coatings on Aluminum AlloysAF93-144TITLE: Sol-Gel Deposition of Coatings on Aluminum Alloys

CATEGORY: Exploratory Development

OBJECTIVE: To demonstrate sol-gel deposition of ceramic coatings on aluminum alloys as pretreatments for adhesive bonding.

DESCRIPTION: State-of-the-art processes for pretreatment of aluminum alloys for adhesive bonding or for corrosion protection involve chemically grown, hydrated oxides (anodizing) and the use of chromated corrosion inhibitors. These processes are large water users, and the chromates are toxic and hazardous. Research has shown that ceramic inorganic coatings have the necessary thickness, strength, adhesion, and morphology to function as adhesive bonding on corrosion protection layers. These coatings may be deposited in a controllable manner via nonchemical means such as low temperature, low pressure chemical vapor deposition, laser assisted pyrolitic decomposition, plasma-enhanced deposition processes, and sol-gel processes. The chemical layers so formed would be anhydrous, not subject to the temperature limitations of state-of-the-art coatings and would be formed via environmentally acceptable processes. The Phase I goal is to demonstrate process feasibility. Inorganic, anhydrous coatings shall be deposited on aircraft grade structural aluminum alloys using the sol-gel process. The coatings shall be characterized as to chemical composition, morphology, thermodynamic stability, hydrolytic stability, corrosion resistance and bondability. Coating influence on metallic alloy properties such as fatigue effects, shall be evaluated. Demonstrate the feasibility of using environmentally acceptable nonwater using process for pretreatment of aerospace structural aluminum alloys. Phase II goal is to optimize coating characteristics (thickness, density, adhesion, etc.) and process parameters to obtain best

balance of adhesive bonding and corrosion resistance in bonded joints. Phase III would scale up and transition/transfer process to Air Force Logistics Centers, and industrial partners write specifications and standards and develop required data base.

AF93-145TITLE: Optically Clear Canopy Repair AdhesiveAF93-145TITLE: Optically Clear Canopy Repair Adhesive

CATEGORY: Exploratory Development

OBJECTIVE: Demonstrate use of optically clear, UV cure adhesives for rapid repair of damage to plastic canopies.

DESCRIPTION: State-of-the-art rapid repair for plastic canopies involves the use of sealants, metal plates, and metallic fasteners. The repairs are complex and obstruct the view of the pilot because they are opaque. R&D has shown that UV curing adhesives can be used to effect rapid, simple, and clean repairs to damaged plastic canopies. These adhesives are not optically clear nor are they formulated for the specific repair task of interest. Work is needed to develop optically clear, UV curing adhesives formulated for the rapid repair of plastic canopies. Phase I goal is to demonstrate the feasibility of making transparent, structural, battle damage repairs to plastic canopies and windscreens. Phase II is to develop materials (kits) and process for field level test and evaluation. Generate materials and process specifications and the necessary data base to support the application. Phase III would transition to AFLC and advanced battle damage repair teams. Add repair to battle damage technical order. Kits stock listed.

AF93-146TITLE: More-Electric Aircraft Power System TechnologiesAF93-146TITLE: More-Electric Aircraft Power System Technologies

CATEGORY: Basic Research

OBJECTIVE: Explore and develop electrical components and devices applicable to future and retrofit "more-electric" aircraft.

DESCRIPTION: Proposals should address one or more of the following: (a) 270 Vdc electric bus components; including batteries, motors, and generators; (b) fault-tolerant power control devices and arc detection and suppression schemes, including photonics; (c) source to load dynamic models, including load and fault transients; (d) lightweight electrical and mechanical energy conversion devices; (e) electromagnetic interference/electromagnetic compatibility (EMI/EMC) mitigation schemes; (f) integrated thermal control of power system elements; and (g) 10-30 MPa pneumatic storage/compressor technology. Phase I goals include analyses and proof-of-concept experiments. Phase II goals include detailed analytical derivations and prototypical device and/or hardware demonstrations. Phase III goals include demonstrating flight-qualified, flight-ready hardware.

AF93-147TITLE: Power ElectronicsAF93-147TITLE: Power Electronics

CATEGORY: Basic Research

OBJECTIVE: Explore and develop power electronics devices for future 1kW-150kW aerospace power system applications.

DESCRIPTION: Proposals should address one or more of the following: (a) power control and conditioning technologies; (b) advanced inverter topologies; (c) high temperature (200 degree C or greater) power active and passive devices; (d) high frequency (75 kHz and above) conversion low loss techniques; (e) high frequency low loss (75 kHz and above) magnetics and capacitors; and (f) high heat flux thermal control techniques and integral lightweight

structures and packaging. Phase I goals include analyses and proof-of-concept experiments. Phase II goals include detailed analytical derivations and prototypical device and/or hardware demonstrations. Phase III goals include demonstrating flight-qualified flight-ready hardware.

AF93-148TITLE: Advanced Energy ConversionAF93-148TITLE: Advanced Energy Conversion

CATEGORY: Basic Research

OBJECTIVE: Characterization and application of advanced energy conversion materials.

DESCRIPTION: Proposals should address (a) semiconductor; (b) capacitor; (c) magnetic; (d) superconducting; (e) dielectric; (f) heat transfer and working fluids; (g) refractory; (h) electrochemistry; and (i) composite materials applicable to aerospace power system applications. Phase I will focus on characterization of properties of these materials as related to envisioned applications and quantitative assessment of realizable benefits/improvements to system/subsystem performance. Phase II goals will focus on improvements to properties, batch manufacturing methods, and demonstration of the material in a prototypical configuration or embodiment. Phase III is expected to transition the Phase II products to a specific application via design, resolution of unresolved production and manufacturing issues, and/or complete demonstration of material compatibility, life, and/or properties for a specific application.

AF93-149TITLE: Physics of Plasma ProcessingAF93-149TITLE: Physics of Plasma Processing

CATEGORY: Basic Research

OBJECTIVE: Explore and characterize the plasma physics fundamentals governing interfaces produced by plasma-enhanced deposition.

DESCRIPTION: Proposals should address plasma processing and plasma-enhanced deposition science related to (a) semiconductors/contacts and (b) dielectric (e.g., diamond) films on conductors, semiconductors, and refractories. Phase I efforts will focus on identifying physical mechanisms and limitations governing important interfaces and their processing parameters (e.g., uniformity, topography, rates of deposition, defects) related to the plasma, surface interaction problems. Phase II efforts will focus on demonstrating process control and validating improvements. Phase III efforts will demonstrate specific device applications of the improved plasma processing.

AF93-150TITLE: Arbitrary Grid Patching for 3-Dimensional Compressible Flow SimulationsAF93-150TITLE: Arbitrary Grid Patching for 3-Dimensional Compressible Flow Simulations

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate methodology for transfer of data between computational zones with arbitrary grid alignments.

DESCRIPTION: In order to design/evaluate advanced airbreathing propulsion components and systems, computational fluid dynamics (CFC) techniques are being used. However, due to the complex geometries being considered, grid generation has become a major difficulty. For analyzing complex geometries with advanced CFD codes, grid generation is complicated by the requirements for a single zone grid. Some advanced CFD codes have grid blocking where a single grid can be split into multiple sections; however, the grid lines must continuously pass through the block boundaries. Other CFD codes have arbitrary zone interfacing; however, the interfacing is rarely done in a conservative manner making the results suspect. Phase I is to demonstrate a practical, accurate, and conservative zone

data transfer methodology applicable to full Navier-Stokes flow simulations. The method should be applicable to overlapping and nonoverlapping 3-dimensional grids, as well as steady-state or time-dependent simulations. The transfer of conservation, primitive, and characteristic variables should be considered. Phase II is to incorporate the developed methodology into a CFD code that has been well calibrated for internal, high-speed flows with finite rate chemistry. It is also desirable, but not required, that this code already be in use by the Air Force for these problems. During Phase III the contractor shall deliver and demonstrate the code to the Air Force including installation on a designated computer, complete software listings, code operating instructions, and a training class.

AF93-151TITLE: High Mach Combined Cycle Engine TechnologiesAF93-151TITLE: High Mach Combined Cycle Engine Technologies

CATEGORY: Basic Research

OBJECTIVE: Develop key technologies for combined cycle engines operating from Mach 0 to 6 flight speeds.

DESCRIPTION: Investigations of combined cycle propulsion systems have shown turboramjets and air-turborockets to be very attractive propulsion concepts at Mach 0 to 6 flight speeds. Both concepts combine the flexibility and efficiency of turbomachinery at flight speeds Mach 0 to 4 with the simplicity, low weight and high specific impulse of the ramjet in the Mach 3 to 6 flight range. Currently, plans are underway to develop technologies for both a turboramjet and an air turborocket under the High Mach Turbine Engine Technologies (HiMATE) program. Under this program, technologies which would be applicable to either cycle are of primary interest. The proposal must demonstrate an understanding of the HiMATE program and its goals. Examples of technologies which are of interest include air intake systems, exit nozzles, solutions to reduce the length and weight of the inlet and nozzle components, ramburner structures, ramburner fuel injection/flameholding schemes, endothermic fuel reactor/engine integration, heat exchangers using either fuel or a nonexpendable fluid to cool air, ramburner cooling techniques and air driven power generation devices. Proof of concept testing is preferred, but analytical investigations will also be considered. The goals of Phase I will be to identify a novel concept, quantify its payoff, and conduct a small-scale experiment to demonstrate concept feasibility. If a strictly analytical approach is proposed, sufficient analysis must be performed to demonstrate some degree of concept feasibility and plan experiments for Phase II. Larger scale development would be undertaken in Phase II. The proposal should include plans for Phase II testing which include identification of appropriate facilities. The goals of Phase III would be to integrate the components developed in Phase II into a combined cycle engine demonstrator and evaluate its performance.

AF93-152TITLE: Diagnostic Measurements of Supersonic Flow FieldsAF93-152TITLE: Diagnostic Measurements of Supersonic Flow Fields

CATEGORY: Basic Research

OBJECTIVE: Develop analytical techniques for mapping scramjet flow fields based on fuel penetration and mixing experiments.

DESCRIPTION: Obtaining accurate measurements of the various flow parameters - velocity, temperature, density (or pressure), and species concentrations - in a scramjet test-cell environment, without disturbing that which is measured, is a formidable task. Flow field mapping is important to the understanding of fuel penetration, mixing, and combustion, and provides a data base for the validation of computional fluid dynamics (CFD) models. Measurements of recombination in the exhaust nozzle, and of skin friction and heat transfer on all surfaces likewise will further understanding of supersonic combustion. Electronic processing of the instrumentation signals is an integral part of any mapping technique. The goal of the Phase I program will be to demonstrate the feasibility of the measurement method in a shock tunnel or blow-down tunnel. In Phase II, the contractor will develop the concept so that it can be used in a production mode in a test cell. It must tolerate high temperatures, high levels of vibration, and extended periods of continuous operation while requiring a minimum of recalibration and maintenance. A complete operating system, to be

utilized in a supersonic flow test facility, would be a deliverable item. Phase III would see the concept applied to scramjet combustor development programs.

AF93-153TITLE: Innovative Structural Concepts for Turbine Engine ComponentsAF93-153TITLE: Innovative Structural Concepts for Turbine Engine Components

CATEGORY: Basic Research

OBJECTIVE: Develop structural concepts for advanced material systems, including composites, for turbine engine component applications.

DESCRIPTION: The demands for improved performance in future gas turbine engines will require the use of advanced material systems, such as Metal Matrix Composites, Ceramic Matrix Composites, and Intermetallic Materials. These material systems have very different properties and characteristics from conventional materials; for example, fiber-reinforced composites exhibit strong anisotropy and fiber/matrix interactions. Experience has shown that a simple material substitution approach is an inefficient design method and that new approaches are needed to exploit advanced materials. Phase I will explore the feasibility of a new concept or concepts, through analysis or small-scale testing to demonstrate the potential merits of the concept. Further development under a Phase II effort should lead to the full demonstration of the concept, allowing it to be applied to engine components in Phase III.

AF93-154TITLE: Neural Network Technology for Jet EnginesAF93-154TITLE: Neural Network Technology for Jet Engines

CATEGORY: Basic Research

OBJECTIVE: Design and evaluate neural network models for robust, fault tolerant, turbine engine controls applications.

DESCRIPTION: Future aircraft and turbine engine controls will be more robust, require higher levels of fault tolerance, and have reduced life cycle cost. Currently, fault tolerance is achieved by multiple levels of hardware and software redundancy, in addition to separate diagnostic systems to diagnose hardware and software faults. These systems impose a significant cost and weight penalty on the control system. Advances in neural network technology make feasible the development of significantly more robust control models, with inherent fault tolerance. Candidate neural network models should address one or more of the following technology areas: engine vibration monitoring, robust control, sensor/actuator fault detection, and control system fault tolerance. The goal of Phase I is to investigate neural network models applied to one or more of the turbine engine control technology areas. The results should demonstrate the applicability of neural networks for advanced turbine engine controls in terms of performance and development cost reduction. A detailed design, fabrication, and test of a prototype neural network controller shall be conducted in Phase II. An engine demonstration test of flight worthy hardware will be conducted in Phase III.

AF93-155TITLE: Detection of Contamination in Synthetic Lubricants Prior to ReclamationAF93-155TITLE: Detection of Contamination in Synthetic Lubricants Prior to Reclamation

CATEGORY: Basic Research

OBJECTIVE: Develop methodology for on-site detection of contaminated materials that limit reclamation of synthetic turbine engine lubricants.

DESCRIPTION: Typically, used synthetic turbine engine lubricants are collected on-site then sold to contractors at

relatively low prices for use as plasticizer. The potential for contamination of the gathered lubricants with other products, especially those that contain halogenated products, prevents use of a previously developed reclamation process. That process was successfully developed during the l980's; however, it was not cost-competitive compared to purchase of new lubricants, due in part to the problem of contamination. Hence, technology that could effectively detect contaminants on-site by nontechnical personnel would significantly increase the potential for reclamation. Due to increasing environmental concerns associated with the use and disposal of lubricants and associated products, reclamation may not only be viable, but the preferred method for managing disposition of those materials. This Phase I effort will identify on-site monitoring technology to detect contamination of synthetic lubricants and determine the feasibility of developing the required technology. The Phase II effort will develop and demonstrate the required technology. Phase III would consist of commercialization of the on-site contaminant monitoring technology for use in a wide variety of applications.

AF93-156TITLE: Advanced Digital Control Methodologies for Turbine Engine Magnetic BearingsAF93-156TITLE: Advanced Digital Control Methodologies for Turbine Engine Magnetic Bearings

CATEGORY: Basic Research

OBJECTIVE: Develop advanced digital control methodologies and reduced controller hardware size for turbine engine magnetic bearings.

DESCRIPTION: Active magnetic bearings represent an innovative approach to aircraft engine rotor support with the potential of providing significant benefits not possible with conventional rolling element bearings. The successful application of active magnetic bearings would result in engines with no oiling systems, higher rotor speeds, reduced blade tip and seal clearances, reduced weight, and enhanced rotor dynamic control. However, advanced digital controls technology has been identified as a critical area for successfully achieving an operational aircraft engine magnetic bearing system. The digital controller must be able to reliably accommodate and control engine rotor dynamic behavior and thrust loading throughout the entire engine operating range while maintaining low power consumption, fault-tolerance, and compact size/weight. Phase I goals will include the design and analysis of an advanced active magnetic bearing digital controller that incorporates innovative control methodology techniques, increased reliability, and miniaturization. Issues such as system architecture, component technology, circuit configuration, power efficiency, and stability margin will be explored. The controller will be designed for a large (approximately 30,000-lb thrust) man-rated, advanced, turbojet engine. Phase II activities would include the detailed design, fabrication, and testing of the selected controller configuration on a full-scale magnetic bearing rotor support system. Phase III goals would be to apply the controller concept to turbine engine magnetic bearing systems or demonstrator engines.

AF93-157TITLE: Indicating Additive for Underground Fuel SpillsAF93-157TITLE: Indicating Additive for Underground Fuel Spills

CATEGORY: Basic Research

OBJECTIVE: Develop an indicating additive for aviation turbine fuels to identify underground fuel spill.

DESCRIPTION: As underground fuel storage tanks age, the likelihood of underground fuel spills increases. If not detected rapidly, underground fuel spills can contaminate the ground surrounding the fuel tank and potentially enter the groundwater. In some locations, several different fuels may be stored (i.e., jet fuel, gasoline, diesel) in a single tank farm increasing the difficulty of determining which tank is leaking. Phase I of this program will be to identify and test the feasibility of an additive for aviation turbine fuel (JP-8) that can be used to detect a leak quickly and easily. The additive shall be compatible with all existing fuel system materials and must not alter fuel performance requirements. In addition, the additive shall be nontoxic and not become a hazardous material in the environment. Phase II of this effort will be to test the additive for compatibility of fuel system materials and demonstrate the performance of the

material in a field situation. Toxicity testing will be conducted as required. Phase III of this effort will be to market the additive to government agencies and potential commercial users such as commercial airlines and fuel distribution companies.

AF93-158TITLE: New Concepts and Innovations for Aeronautical Systems/SubsystemsAF93-158TITLE: New Concepts and Innovations for Aeronautical Systems/Subsystems

CATEGORY: Basic Research

OBJECTIVE: Develop new concept and innovations for aeronautical systems/subsystems for possible emerging systems and update of existing systems.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of aeronautical systems/subsystems research, development, and acquisition. It is intended to provide latitude to the innovator to include areas not specifically addressed by other specific aeronautical topics. This general area covers the full spectrum of Air Force aeronautical missions (i.e., tactical, airlift, mobility, strategic, transatmospheric, tactical relocatable targets, etc). Emphasis is placed on potential long term planning concepts. Topics as diverse as new weapon system concepts and improved operational techniques con be submitted. Innovations in technologies that are currently available only from foreign sources or from limited sources in the United States are specifically encouraged. Additionally, innovation proposals which address Logistic Technology Needs are encouraged. Some other areas of interest are high energy fuels, maintenance free systems, and innovative R&D organizational concepts. This topic is structured to provide a maximum of innovative flexibility to prospective participants. Therefore, in the Phase I proposal briefly address the anticipated phase II effort and potential for Phase III.

AF93-159TITLE: Innovative Tools for Hypersonic Systems PlanningAF93-159TITLE: Innovative Tools for Hypersonic Systems Planning

CATEGORY: Basic Research

OBJECTIVE: Develop planning tools for efficient development planning future hypersonic system.

DESCRIPTION: Fosters the development of innovative and effective design, modeling, systems engineering, mission analysis, mission effectiveness, cost estimating, schedule planning, supportability analysis, mission planning, risk assessment and technology assessment tools for Air Force development planners of future hypersonic systems. Future hypersonic systems include exoatomaspheric/endoatmospheric aero-space vehicle for space support and military poser projection, supersonic civil/military transport aircraft, mach 6-8 airbreathing hydrocarbon-fueled aircraft, mach 10-12 hydrogen fueled airbreathing aircraft, mach 15-20 boost-glide vehicle weapon, and mach 6-8 cruise missile. Innovation testing concepts and methodologies for test facilities and test capabilities for Air Force and national laboratories and test centers are also desired. As this is a very broad topic, in the Phase I proposal briefly address the anticipated Phase II effort and potential for Phase III.

AF93-160TITLE: More Supportable T-38A as a Bomber Fighter Training System PlatformAF93-160TITLE: More Supportable T-38A as a Bomber Fighter Training System Platform

CATEGORY: Basic Research

OBJECTIVE: To determine solutions for streamlining flight line maintenance to increase T-38A utilization rates.

DESCRIPTION: The change in Air Force pilot training to a dual-track (Bomber/Fighter vs. Tanker/Transport)

program, coupled with system modifications performed by the Pacer Classic program, will extend the life of the T-38A until 2017. Research is required to investigate potential solutions for decreasing the time required to service the aircraft between training sorties. This would increase aircraft utilization rates and improve "surge" capability. Phase I activity would establish a baseline by reviewing present aircraft servicing procedures and whether anticipated future force structure decisions (base closing, changes in rate of pilot training production, aircraft attrition) will drive requirements that warrant procedural or system changes to T-38A maintenance procedures. Phase II activity would identify specific procedural process improvements and aircraft system upgrades/modifications that would significantly decrease the time required between aircraft sorties for servicing. Thus, this research will identify potential Logistics Requirements for Technology. Phase III should involve prototyping of selected Phase I upgrade(s)/modification(s) to the T-38A aircraft.

AF93-161TITLE: Development of a Decision Support Tool for Development PlanningAF93-161TITLE: Development of a Decision Support Tool for Development Planning

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate the application of an automated decision support tool for long-range acquisition planning.

DESCRIPTION: An automated decision support tool is needed, in Premilestone I Acquisition activities, to assess and prioritize system concept alternatives and supporting technologies based on military operational requirements. This computer-based system must be consistent with the strategies-to-task process. As a minimum, the elements: 1) military mission, 2) military operational requirements, 3) system concept alternatives, 4) functional capabilities of the concepts; and 5) supporting technologies. The automated tool will allow the user to establish priorities and assign a relative importance at any level of the strategies-to-task hierarchy. The system will be capable of maintaining an audit trail of user inputs and system generated output and allow easy retrieval of that information. As a minimum, the output from the decision tool is a rank ordering of system concepts and technologies and an assessment report. The user will be able to conduct sensitivity analyses and query the system to trace a technology linkage back to a specific user requirement or a set of requirements and determine why one technology ranks higher than another. The contractor will examine at least two feasible analytical approaches, such as Quality Function Deployment (QFD), for developing the system, and recommend the most desirable, and give the rationale for their recommendation. The structure of each approach should be generically applicable to any Air Force mission area. The contractor will develop the decision support tool and associated documentation and demonstrate the system. The phase I deliverable will be a working prototype system with source code and user's manual. Additionally, the contractor will provide a study report that verifies that the system is based on sound analytical methods and demonstrate the application with a realistic example. At the end of Phase II the contractor will deliver a completed and fully tested computer-based system, source code, user's manual, and programmer analyst manual. The contractor will perform a full demonstration of the system for the mobility mission area. Phase III should involve the marketing of this Development Planning Tool as a standardized long-range acquisition planning tool within the DoD.

AF93-162TITLE: Aerial Refueling Communication Under Radio Silent ConditionsAF93-162TITLE: Aerial Refueling Communication Under Radio Silent Conditions

CATEGORY: Basic Research

OBJECTIVE: Develop system design approaches to provide radio silent conditions during aerial refueling procedures between tanker/receiver aircraft.

DESCRIPTION: Currently, when the taker boom is inserted into the receiver receptacle, through-the-boom communication is established between KC-135/KC-10 tanker aircraft and the receptacle equipped receiver aircraft. Prior to boom-receptacle contact, during radio silent conditions, communications between aircraft is accomplished

through the use of aircraft lights. Similar limitations also exist during the entire aerial refueling sequence when using probe-drogue systems.

A system which could provide verbal communications during all phases of aerial refueling, while not compromising radio silent conditions, is required to eliminate these operational problems. The system should operate at tanker/receiver distances of 3/4 -1 mile apart before tanker/receiver hookup, and be capable of communication to each receiver aircraft refueling off the tanker's aerial refueling boom and/or wing probe-drogue system(s) position. The communication system must be compatible with single seat receiver aircraft. During Phase I it is requested that candidate communication systems be analyzed and one or two potential candidate systems be selected for continuation into Phase II. In Phase II, the contractor would design, develop, and provide a flightworthy prototype system for the tanker and receiver aircraft. Phase III would involve a flight test and service test on the prototype system followed by limited/full production.

AF93-163TITLE: Wear/Vibration Criteria for FastenersAF93-163TITLE: Wear/Vibration Criteria for Fasteners

CATEGORY: Basic Research

OBJECTIVE: Investigate wear/vibration criteria for fasteners to develop prediction models for depot service

DESCRIPTION: Fasteners of various types are used extensively in several applications over the entire aircraft. With the passage of time, some of the fasteners tend to "lose their grip" especially when used in thin sheet applications. It is not clearly understood whether this phenomenon is due to wear of the components being fastened, wear on the fasteners, their location, relative hardness of the fasteners with respect to the material being fastened, operational loads, galvanic action because of dissimilar metallurgy of a combination of some or all of the above factors. This SBIR will select a fighter aircraft (e.g. F-15) and identify the different types of fasteners, location, metallurgy, operational loads, typical duty cycles and vibrational frequencies. It will then be determined which fasteners are more prone to lose their grip and a prediction model will be developed to determine when the aircraft would be scheduled for service checks. In Phase II, the contractor shall investigate in detail problems with these fasteners and develop a prediction technique/model for determining service live. In Phase III, the contractor shall verify these models against field data.

AF93-164TITLE: Armament ResearchAF93-164TITLE: Armament Research

CATEGORY: Exploratory Development

OBJECTIVE: Develop innovative concepts in areas associated with air deliverable munitions and armaments.

DESCRIPTION: New and innovative ideas/concepts and analysis methodologies are desired in the area of air delivered non- nuclear munitions and armaments. These include bombs, submunitions, warheads, projectiles, fuzes (including safe and arm devices for air-to-air missiles), dispensers, seekers, explosives, carriage and release equipment, aerodynamic and structural technologies, fiber optics, solid-state inertial components, exterior ballistics, and lethality and vulnerability assessment techniques. Some examples of desired research are: low drag/observable weapon airframes; conformal/internal carriage techniques; millimeter wave-seekers for mid-course and terminal guidance; sensor fusion; heavy metal, self-forging fragment warheads; heavy-metal shaped charges; long-rod penetrators; reactive fragment warheads; computational fluid dynamics including interactive grid-generation techniques, and warhead hydrocode-assessment techniques; hard-target weapon technology; and autonomous guidance.

AF93-165TITLE: Computerized Dynamic Chemical Dispersion Model for Reactive Materials ApplicationsAF93-165TITLE: Computerized Dynamic Chemical Dispersion Model for Reactive Materials Applications

CATEGORY: Exploratory Development

OBJECTIVE: Develop a chemical dispersion computer model for modeling the effects of reactive materials.

DESCRIPTION: The most commonly used chemical dispersion models account for the dissemination of many different compounds, but none are dedicated solely to reactive materials. The current models are effective in determining the range of contamination of different chemicals in the event of spills, accidents, etc. But, there are no known models that will predict the reaction products of reactive chemicals in the area near the point of release. For example, the effect of the reactive chemicals or by-products on the ground, air, plant material, etc. The goal of this task is to develop a computer model that will predict reaction products and downwind drifts so that all of the possible environmental outcomes of a reactive weapon test can be accounted for. The model should perform all of the calculations necessary for prediction using specified quantities of reactive material for any type of dispersion method (e.g., a spill, an explosive dispersion, an impact dispersion). The model must also be able to calculate contamination contours from the point of release as well as give the expected concentration of contamination at any particular distance from the point of release. Phase I of this SBIR should consist of an analysis of existing prediction techniques, collection of data on the reactive materials to be included in the proposed model, and designing the dynamic chemical dispersion model. In Phase II the model design will be implemented, the software written, and the documented model delivered for use by the Government. Many commercial uses are envisioned for predicting environmental hazards from reactive chemicals.

AF93-166TITLE: Advanced Airborne Interceptor Simulator (AAIS)AF93-166TITLE: Advanced Airborne Interceptor Simulator (AAIS)

CATEGORY: Advanced Development

OBJECTIVE: Develop Cooling and Antenna Pointing Techniques for the Advanced Airborne Interceptor Simulator Pod.

DESCRIPTION: The Air Force is developing a test capability to simulate wave forms, modes, and power levels of advanced threat airborne interceptors. The Advanced Airborne Interceptor Simulator (AAIS) will be a pod mounted simulator designed to achieve a high degree of autonomy possibly including carriage on non test-coded fleet aircraft. The technical challenges of this pod mounted simulator includes pod cooling and antenna pointing. The threat simulator will operate in the 9-10 GHz frequency range with a power output of approximately 3KW. The range of operation should be up to l00 nautical miles with a total field-of-view of sixty to ninety degrees. Innovative concepts are desired to explore various alternatives for cooling a twenty-two inch pod containing the threat simulator. Concepts are also desired to explore alternative means of antenna pointing. A design requirement of AAIS is to successively and accurately point the transmit antenna at multiple targets involved in the test scenarios. Possible sources of data for the AAIS Antenna Pointing System are either the Global Positioning System (GPS) or the Air Combat Maneuvering Instrumentation System (ACMI). Methods are sought to slave/interface the AAIS antenna to the TSPI source in the pod, thus allowing the transmitter to illuminate the targets.

AF93-167TITLE: Two-Dimensional Electronically Steerable Monopulse Millimeter Wave AntennaAF93-167TITLE: Two-Dimensional Electronically Steerable Monopulse Millimeter Wave Antenna

CATEGORY: Exploratory Development

OBJECTIVE: Develop a two-dimensional electronically steerable monopulse millimeter wave (MMW) antenna for air-to-air missile seekers.

DESCRIPTION: One-dimensional electronically steerable MMW antennas have been developed but they are not suitable for the dynamic environment of air-to-air missile engagements. MMW phase shifter and gain control

component technology has improved sufficiently so that two-dimensional electronic beam steering is now feasible. Two-dimensional electronically steerable monopulse antennas, capable of handling high scan rates without the use of gimbal systems, would greatly enhance the performance of air-to- air missiles. Moreover, the use of a MMW radar in air-to-air scenarios significantly reduces susceptibility to counter- measures and increases the probability of kill because of higher guidance angle accuracies. The technical challenge of this project is to develop the low cost components needed to construct a two-dimensional electronically steerable MMW monopulse antenna sized for an AMRAAM class missile. The challenge also includes the development of a monopulse feed network to output the sum, delta azimuth, and delta elevation channels. Recent developments in size reduction and increased power output of MMW solid state transmitters provide the technology base. Phase I includes analysis and design of the antenna and monopulse feed network suitable to implement MMW antennas with beam steering circuitry. Phase I will culminate with the recommendation of a candidate approach to incorporate the MMW components into the antenna and feed network design to be demonstrated in Phase II. Phase II includes the laboratory demonstration of the components of the two-dimensional electronically steerable monopulse MMW radar antenna designed in Phase I. The demonstration should accomplish two-dimensional beam steering. Phase III of this SBIR task is to produce a prototype antenna sized to fit an AMRAAM-class missile. This antenna would have to be capable of electronically steering the beam in two dimensions and be capable of handling output power loads of 250 watts average.

AF93-168TITLE: Solid State Materials for Spatial Light Modulators AF93-168TITLE: Solid State Materials for Spatial Light Modulators

CATEGORY: Exploratory Development

OBJECTIVE: Develop and test new, innovative materials for use in spatial light modulators.

DESCRIPTION: The Air Force has considerable investment in programs relating to optical processing and optical computing. Light modulation devices are used in many processing techniques. The materials used to effect the modulation often have slow response times or require high voltages. Materials are needed which can modulate an optical beam rapidly and with as low a voltage as possible. Response times of less than 10^{-6} sec and voltages of 100 volts or less are desired. Materials which modulate wavelengths from .4 to 12 micrometers are sought, although it is not intended that the same material cover this whole spectral region. Materials with good figures of merit for modulator materials should be considered. Eventual use of the materials in a two-dimensional spatial light modulator is expected. Phase I is intended to be a survey of existing knowledge, theoretical development for prediction of performance potential of new materials, and demonstration of new materials if possible. Phase II is to consist of development of new materials based on results of Phase I and the design and fabrication of a limited-scale pixelated device to function as a two-dimensional spatial light modulator.

AF93-169TITLE: Innovative Techniques for Optical Pattern Recognition/Optical CorrelationAF93-169TITLE: Innovative Techniques for Optical Pattern Recognition/Optical Correlation

CATEGORY: Exploratory Development

OBJECTIVE: Develop innovative techniques for optical pattern recognition/optical correlation.

DESCRIPTION: Traditional optical pattern recognition uses two- dimensional correlation to accomplish acquisition and identification. These methods include conventional two- dimensional lenses, spatial light modulators, and optical components. The optical systems using these methods are subject to certain size constraints in order for these elements to perform their function. In addition, two-dimensional modulators currently limit performance of the optical correlator. It is the purpose of this program to investigate unconventional techniques for processing of two-dimensional information. These may include one-dimensional processing, hybrid (digital/optical) processing, acousto-optic processing, integrated optic processing, etc. Phase I includes design and initial demonstration of the concept. Phase II

is to include a full-scale packaged correlator which is to be flight tested by the Government. The complete pattern recognition system/correlator to be demonstrated in Phase II is to be small (less than l cubic foot) and light (less than 44 pounds).

AF93-170TITLE: Low Cost Aerodynamic Control Surfaces for Compressed Weapon CarriageAF93-170TITLE: Low Cost Aerodynamic Control Surfaces for Compressed Weapon Carriage

CATEGORY: Exploratory Development

OBJECTIVE: Develop innovative low cost methods and devices for weapon folding aero control surfaces.

DESCRIPTION: A continuing problem in carrying weapons in conformal or internal carriage aircraft is the interference of fixed wings and control surfaces with the aircraft structure. Many complex mechanisms for folding weapon aero surfaces have been employed throughout the years to enhance compressed weapon carriage and employment from launch tubes and weapon bays. Typically these mechanisms have been complex, costly, and less reliable than desired. A new technique to solve this problem in a simple, inexpensive and highly reliable manner is needed. The goal of this program is to develop mechanisms and materials which will allow the surfaces to be efficiently packaged with little or no increase in weapon diameter, and then deploy at weapon release to provide the required control and stabilization. The technical challenge is to identify suitable metal or composite materials, aero surface materials, develop innovative low cost mechanisms which will allow compressed carriage and deployment, provide the necessary control authority, and withstand the dynamic environment. Both subsonic and supersonic carriage and employment consistent with air-to-surface and air-to-air weapon envelopes are required. Phase I of this SBIR should concentrate on analyzing and defining folding mechanism concepts, surveying potential materials, conducting trade studies, and generating preliminary designs of the preferred concepts. Phase II should include the final design, ground deployment test, wind tunnel test, and structural test of the selected aerosurface concepts.

AF93-171TITLE: The Role of Texture in Directed Energy Warhead Liner Performance AF93-171TITLE: The Role of Texture in Directed Energy Warhead Liner Performance

CATEGORY: Exploratory Development

OBJECTIVE: Investigate Basic Metallurgical Properties and Predict How These Properties Affect Warhead Liner Performance.

DESCRIPTION: Most metals exhibit anisotropic behavior where certain crystallographic orientations exhibit higher mechanical properties than other orientations. Copper has traditionally been the leading choice of directed energy warhead liner material because of ductility, ease of production and effectiveness. Although copper has been a successful liner material, requirements dictated by today's targets necessitates new choices which are more dense with higher dynamic properties. There are other metals which are higher in density and posses low work hardening properties at room temperature. These metals must be investigated to determine their dynamic mechanical properties and optimal initial crystal orientation (textures) and how these parameters affect the final penetrator deformation path and effectiveness. This effort should result in the selection of a higher performance liner material. Phase I of the SBIR task is expected to discover an optimal crystallographic orientation for one promising new liner material. The final selection should demonstrate both the feasibility and efficacy of the material choice. Phase II is expected to fully develop the liner material selected and apply it to a directed energy warhead test. The product should exhibit a new and unique directed energy warhead liner material selection as well as demonstrate a methodology for making future selections.

AF93-172TITLE: Target Vulnerability Assessment Codes and Computational Continuum Mechanics Codes SynergismAF93-172TITLE: Target Vulnerability Assessment Codes and Computational Continuum

Mechanics Codes Synergism

CATEGORY: Basic Research

OBJECTIVE: Integrate the fundamental physical approach of continuum mechanics codes into conventional weapons target vulnerability methodologies.

DESCRIPTION: Vulnerability analysis methodologies have been developed over the past thirty years to assess the broad ranges of weapons/target interactions, allowing weapon developers to make difficult design decisions. During the same period, cost effective and accurate computational continuum mechanics codes (hydrocodes) have been developed for detailed weapon/target interaction issues. These developments have been possible due to the availability of more powerful computational resources at reduced cost and enhanced understanding of the behavior of materials under extreme loading conditions. The complexity of targets, changing delivery conditions, smart weapons, precision guidance, and an increasingly broad range of possible kill mechanisms frequently stretch the empirical data bases that are the core of many current vulnerability codes beyond their credible limits, requiring extensive and often prohibitively expensive additional testing. The technical challenge is to integrate, through links with hydrocode technology, as much fundamental physics into vulnerability methodologies as is necessary to achieve accurate assessments of weapon concepts being analyzed. Modified vulnerability methodologies relying on a computational data base to augment existing experimental data need to be explored. Such an approach, for example, might recognize that fracture characteristics of a target material for an armor penetration process fall outside the range of materials used to develop point burst models being used, and lead to a sequence of hydrocode calculations to build a data base in a format usable by the analysis code. Compatibility of data structures, and capacities to communicate between codes with minimal degradation of technical content is essential. Proposals should be limited to one of the following classes of engagements with its perspective target characteristics: air-to-air, air-to- ground fixed hardened targets, or air-to-ground heavy armor mobile targets. The results of Phase I should confirm the proof of concept by exercising a software subset of the overall methodology capable of demonstrating the approach. Phase II would develop the complete software solution proposed and apply it to several applications, demonstrating the validity of the approach. Phase III is commercial support of valid DoD requirements.

AF93-173TITLE: Enhanced Lethality Thru Tailored ReactionsAF93-173TITLE: Enhanced Lethality Thru Tailored Reactions

CATEGORY: Exploratory Development

OBJECTIVE: Increase warhead lethality through a tailored blast pulse or reactive fragment.

DESCRIPTION: Much of the energy from a conventional high explosive warhead is wasted. The fragments may pass directly through the target, carrying most of their kinetic energy with them. The blast, even when the warhead is buried beneath a runway, tends to vent itself; its energy literally going up in smoke. If the fragment were to 'explode' in the target the lethality would dramatically increase. The fundamental goal of this task is to demonstrate warhead improvement based on the principles of multi-phase, multi-material reactions, tailored reaction rates, equations of state of soil, terminal ballistics of reactant filled fragments, and reacting flow in turbulent media. Successful explosive modes, improved theoretical concepts, or new experimental techniques could provide tools to weaponize this promising technology. The technical challenge includes the lack of previous work in this area, the heterogeneous nature of the materials, and the variety of potential mechanisms. The Phase I effort should clearly define the approach to obtain tailored blast or reactive fragment warhead designs, improved theoretical concepts, or experimental techniques. Phase II is expected to fully develop the approach and apply it to the terminal ballistics, reactive flow, tailored rate or other pertinent warhead technology area.

AF93-174TITLE: Passive Millimeter Wave ImagingAF93-174TITLE: Passive Millimeter Wave Imaging

CATEGORY: Exploratory Development

OBJECTIVE: Obtain one meter cross range resolution at one kilometer employing innovative passive millimeter wave imaging.

DESCRIPTION: Recent developments in Millimeter Wave Microwave Monolithic Integrated Circuits (MIMIC) now permit the employment of high resolution focal plane array techniques for passive millimeter wave imaging. The arrays along with associated optics, electronics and circuitry for image processing and display, can all be constructed at very affordable costs. Still to be achieved, however, is sufficient MMW image resolution to perform the Automatic Target Recognition function. It is believed that through proper array element layout and signal processing techniques, that cross range resolution on the order of one meter can be achieved. Phase I objectives will be to investigate potential superresolution techniques, to design, investigate, and simulate the performance of various focal plane arrays and associated optics, and to propose a candidate approach to be developed and demonstrated in Phase II. The design shall be constrained by an aperture diameter no greater than 30 centimeters. Phase II will include a laboratory demonstration of an imaging array module capable of three meter resolution or less. The demonstration hardware must be transportable and of a size such that demonstrations may be conducted from the tower atop Building l3A of the Wright Laboratory Armament Directorate, Eglin AFB, FL. Phase III is expected to provide a prototype imaging device constructed from replicated Phase II modules with combined capability of achieving the desired one meter image resolution at one kilometer.

AF93-175TITLE: Explosives with Improved Mechanical PropertiesAF93-175TITLE: Explosives with Improved Mechanical Properties

CATEGORY: Exploratory Development

OBJECTIVE: Develop explosive compositions with greatly increased mechanical strength.

DESCRIPTION: Explosives with improved mechanical properties are desired in future warheads and penetrators. Explosives should retain their integrity during hard target impact. Improvements in tensile strength, compressive strength and stiffness are areas of increasing interest among weapons designers. Phase I should result in the design of explosive formulations with improved mechanical properties. Both explosive performance and mechanical properties should be predicted and the processing method documented. In Phase II poured or cast samples will be prepared and tested by both the contractor and the High Explosive Research and Development Facility at Eglin AFB, FL.

AF93-176TITLE: Infrared Spectral Imaging Radiometer (IRSIR)AF93-176TITLE: Infrared Spectral Imaging Radiometer (IRSIR)

CATEGORY: Exploratory Development

OBJECTIVE: Design and develop an infrared spectral imaging radiometer.

DESCRIPTION: Extensive work has been accomplished by the electro-optics industry in the development of spectral radiometers employing circular variable filter (CVF), dispersive element/multiple detectors and fast Fourier transform spectrometer technology. These systems have progressed to capabilities of high spectral resolution and high spectral rates. Exploitation of focal plane array detector technology will provide these capabilities in high performance aircraft in a compact pod carriage arrangement. The primary goal of this task is to explore the feasibility of integrating the spectrometer technology with the focal plane array detector technology resulting in an IRSIR. The technical challenge will be to provide this capability in the spectral range from 0.2 to l2 micrometers. The design approach should indicate how this range will be covered. Phase I will include a study culminating in a recommendation of a candidate design

approach to be demonstrated in Phase II. Phase II is expected to demonstrate, in a laboratory environment, the candidate approach. This phase should also address the method of recording and analyzing the collected data obtained during testing. Phase III is expected to produce a working IRSIR operating at a spectral resolution and spectral rate to be sponsor approved.

AF93-177TITLE: Replacement Materials for Chromates in Coatings and SealantsAF93-177TITLE: Replacement Materials for Chromates in Coatings and Sealants

CATEGORY: Exploratory Development

OBJECTIVE: Determine the best environmentally benign substitute for chromium compounds in Air Force coatings and sealants.

DESCRIPTION: The United States Air Force would like to reduce or eliminate the use of chromium compounds to reduce heavy metal pollution of the environment. Large amount of chromates are used in Chemical Conversion Coating of Aluminum (MIL-C-5541), Primer Coating of Metals (MIL-P-23377), and Corrosion Inhibiting Sealing Compounds (MIL-S-8l733). Chromates provide outstanding corrosion protection to metals by inhibiting the corrosive action of the environment. Phase I of this SBIR task will include a survey of candidate materials, excluding the heavy metals targeted for elimination, and the collection of information regarding their ability to inhibit corrosion. Analysis of this information will produce a list of candidate materials for replacement of the chromates in the three products referenced above. A test plan will be devised to evaluate the corrosion inhibiting properties of the candidate materials against the currently used chromium compounds. Some preliminary tests of candidate materials in Phase I is desirable. Phase II will consist of incorporating the candidate materials from Phase I into the military products listed above. These products will then be tested using the full gamut of tests contained in the product specifications. Samples of chromate containing products from the qualified products list will also be tested. The tests will be modified in order to gain relative worth (as opposed to pass/fail) information. If successful, Phase III would result in the commercialization of the products.

AF93-178TITLE: Fiber Optic System for Delivery of High Power Laser RadiationAF93-178TITLE: Fiber Optic System for Delivery of High Power Laser Radiation

CATEGORY: Exploratory Development

OBJECTIVE: Develop a fiber optic system to deliver high power Nd:YAG radiation

DESCRIPTION: The Air Force is developing a high power laser system to neutralize unexploded ordnance (UXO) called the Mobile Ordnance Disrupter system (MODS). The use of a laser to neutralize munitions will allow explosive ordnance disposal (EOD) personnel to engage munitions at safe ranges regardless of fuzing type (electronic, mechanical, or magnetic) and case material. Furthermore, the laser damage mechanism will normally cause a low order explosion reducing collateral damage. However, the system is only effective against line-of-sight targets. The primary goal of this initiative is to develop a fiber optic system so the laser beam can be propagated to the target via a non-line-of- sight fiber. This delivery system will provide the added flexibility to acquire and neutralize unaccessible targets. The technical challenge is the development of a method to couple a high power (2000 watt) Nd:YAG laser beam with approximately 20 milliradian beam divergence into a fiber-optic cable with a focusing element on the end to project the laser beam onto the target. The fiber-optic cable will also be used for target acquisition so it must contain a camera lens. The system must be designed so both lenses (focusing and camera) are relatively inexpensive and easily replaced. The Phase I effort will define the system requirements, determine the state-of-the-technology and demonstrate the transmission of the high power divergent, laser beam onto a target in the laboratory. Phase II will require the development of the system, integration with MODS and demonstration of the concept. Phase III will explore agile beam pointing applications such as precision cutting, welding and soldering.

AF93-179TITLE: Fullerene-Based Initiator MaterialsAF93-179TITLE: Fullerene-Based Initiator Materials

CATEGORY: Basic Research

OBJECTIVE: Develop explosive initiator materials using fullerene carbon spheroids to provide isolation between fuel and oxidant.

DESCRIPTION: Fullerene (or buckminsterfullerene) is a metastable microscopic carbon structure, uniquely different from graphite or diamond, that consists of 60-carbon, 76-carbon, or l20-carbon molecules patterned in the form of a geodesic sphere. Fullerene carbon spheroids are inert and large enough to surround small clusters of atoms; it has been shown that each fullerene molecule can encapsulate 3 potassium atoms, for example. The Phase I task is to encapsulate tiny clusters of atomic or molecular fuel (or oxidant) with fullerene in order to provide metastable isolation from an oxidant (or fuel) to create a new type of explosive initiator material. Initial feasibility demonstration will involve successful detonation of at least one such metastable mix of fuel and oxidant via shock, heat, electricity, incident photons, or other means. Subsequent Phase II work will be a concentrated effort to refine and characterize the explosive to optimize its performance and prepare it for qualification testing.

AF93-180TITLE: High Surface Area MaterialsAF93-180TITLE: High Surface Area Materials

CATEGORY: Exploratory Development

OBJECTIVE: Determine phenomena responsible for high surface area nucleation/growth for exploitation as electrode materials.

DESCRIPTION: A substance has relatively high surface area (HSA) if it exhibits an area of at least l00 square meters per gram as indicated by gas absorption tests. HSA materials can provide a means by which a process may proceed in a confined volume or at enhanced speed. Catalytic converters, dimensionally stable anodes, and double layer capacitors are examples of devices which use HSA material either in granular or layered form. Direct processes for precipitation of HSA powder have been developed because of the need for catalysts. However, existing procedures for HSA layer formation are not applicable to a wide variety of materials. The ability to engineer electrodes for specific purposes is therefore quite restricted. Phase I research will involve an analysis of all published data pertinent to the problem of how to grow potentially useful HSA films (such as transition metal oxides, nitrides, and borides) as electrodes for capacitive energy storage. Conductivity, substrate adhesion, electrochemical stability, and double layer capacitance when used with a given electrolyte are major considerations. Ease of fabrication, availability/cost, and growth rate or layer thickness limitations should also be considered. A successful Phase I effort would include a laboratory demonstration of a novel electrode/electrolyte system that offers exceptional energy storage capabilities. Phase II efforts will be directed towards optimization of planar electrode fabrication techniques and packaging of stacked or rolled cells for long term usage.

AF93-181TITLE: High Speed Data Acquisition for FuzingAF93-181TITLE: High Speed Data Acquisition for Fuzing

CATEGORY: Exploratory Development

OBJECTIVE: Design a high speed digital data acquisition system for use with fuze sensors.

DESCRIPTION: Recent technology advances have produced 8-bit flash analog-to-digital (A/D) convertors that are fast enough (300 mega samples per second) for fuze sensor applications while still being affordable and meeting military specifications. There is a requirement to couple these devices with appropriate memory and simplified

controller for fuze sensor applications. The technical challenge is to design the complete high speed data acquisition package into a volume no greater than 2 cubic centimeters. The memory requirements are a minimum of 200 bytes of data. The desire and technical challenge is to extend the design of the high speed memory to l6K bytes. The controller must continually store all data in memory; wrapping around such that pre-trigger information can be obtained. The three main functions of the integrated device are: a) continuous data acquisition (wrapping around) on command from an external source, b) stop acquisition on command from an external source, and c) data transfer to external device. The amount of pre-trigger information available should be user definable and preset before the unit is placed into operation. Phase I program design should show feasibility of the concept and minimum package size along with baseline operating specifications (power requirements, power consumption, heat dissipation, temperature, humidity, "g" loading, etc.). This design should also include interface to a laboratory PC-based computer for data transfer demonstration. Phase II of the program would emphasize construction of several demonstration devices along with testing to determine their actual operating environment limitations. Phase III applications of this device include laser rangefinders, collision avoidance sensors, intrusion detectors, and optical research involving time of flight data.

AF93-182TITLE: Solid State Scanner for Laser Radar (LADAR) SystemsAF93-182TITLE: Solid State Scanner for Laser Radar (LADAR) Systems

CATEGORY: Exploratory Development

OBJECTIVE: Develop a laser radar scanning system which does not use mechanical moving parts.

DESCRIPTION: LADAR systems have been built which use scanning mirrors and other devices to direct the laser beam and return energy. These systems, though very capable of directing the beam in a systematic method, are not very flexible for use in scanning systems which could make better use of the laser beam by scanning in non-linear patterns or dwelling on interesting features based on feedback from a processor. A solid state device which could be scanned in a random pattern on command with little delay would greatly enhance the capabilities of LADAR systems. The device should provide at least a 45 degree by l5 degree scan pattern and operate with laser pulse powers of at least a few kilowatts. The device must be small, lightweight and not produce a large electromagnetic interference signal during operation. The device should not waste or absorb more than ten percent of the energy transmitted or received. Phase I of this project would identify technologies which satisfy this need, determine the theoretical limits of various techniques, and demonstrate the best technique in a laboratory using an applicable laser and pulse rate. Phase II would develop prototype hardware capable of being installed in a working LADAR to demonstrate the capability of the technology.

AF93-183TITLE: Ferromagnetic Polymer Inductive Coupling for FuzingAF93-183TITLE: Ferromagnetic Polymer Inductive Coupling for Fuzing

CATEGORY: Exploratory Development

OBJECTIVE: Design ferromagnetic polymers to enhance efficiency and ruggedness of inductive couplers for penetrator weapon fuzes.

DESCRIPTION: Inductive couplers are foreseen as an implement to modular design of advanced fuzes. It has been demonstrated that in-line fuze circuit modules can be coupled inductively as opposed to ordinary physical connection via conventional means. Ferrite pot cores have been used for increased inductive coupling efficiency, but their brittleness makes them undesirable for hard target penetrator fuze applications. Blending ferrite powders with polymers greatly improves pot core ruggedness, but coupling efficiency suffers since there is no ferromagnetic contribution from the polymer matrix. Likewise, coupling through a polymer fuze housing presents similar problems. What is needed is a ferromagnetic polymer that can be used as a binder with ferrite powder in order to make a high-G impact survivable pot core that has high coupling efficiency. Phase I of this program would include evaluation of ferromagnetic polymers

and a characterization of magnetic and mechanical properties of various ferrite polymer/powder blends. The result of Phase I would be the selection of several material compositions for inclusion in the Phase II fabrication/test program. Phase II would advance this technology towards high impact strength pot core fabrication and include a demonstration of improved inductive coupling efficiency. Copolymerization experiments covering the potential thermoplastic fuze housing materials would be included.

AF93-184TITLE: Emerging Technologies Resulting in Lighter Aircraft, Increased Engine Performance, and Improved Design ToolsAF93-184TITLE: Emerging Technologies Resulting in Lighter Aircraft, Increased Engine Performance, and Improved Design Tools

CATEGORY: Basic Research

OBJECTIVE: Improvements in aircraft structure, scramjet performance, and aerodynamic design technologies.

DESCRIPTION: The National Aero-Space Plane is providing a quantum jump in aerospace technologies by investigating new and innovative solutions. Its goal is a Mach 25 air-breathing scramjet vehicle capable of single stage to orbit. Emerging technologies providing significant performance improvements for the aircraft will be considered. Phase I must show experience and understanding of the relative importance of the technologies. It must also provide detailed drawings, specifications, and test procedures for the proposed application of the technologies. Phase II requires prototype and associated test results demonstrating decreased weight, increased scramjet performance, or improved aerodynamic design tools without increased liabilities. Potential Phase III customers include the five members of the NASP Industry Team, Government laboratories, the computer industry, and the automotive industry.

AF93-185TITLE: Integrally Woven Lightweight High Temperature Composite StructuresAF93-185TITLE: Integrally Woven Lightweight High Temperature Composite Structures

CATEGORY: Basic Research

OBJECTIVE: Lightweight, structurally efficient design approaches for high temperature composite materials using methods of integral weaving.

DESCRIPTION: Advanced, lightweight airframes having structural weight fractions as low as 0.1 are required for future high performance aerospace vehicles, such as the NASP and its derivatives. These vehicles will operate in severe high temperature environments which are beyond the limitations of many current materials. Metallic and nonmetallic composites, such as metal matrix, carbon-carbon and fiber reinforced ceramics, are promising classes of materials having potential application to such future vehicles. Joining methods to achieve structural assemblies using these materials are under development, but much work remains. An alternative to joining, where practical, is to employ integral weaving to greatly reduce or eliminate the required joining of discrete parts. Innovative methods are thus required to achieve basic woven structural shapes for panel and joint regions which are lightweight, structurally efficient, and which exploit the inherent characteristics of the candidate materials. Application areas are for service temperatures greater than 1000°F and include airframe and engine components, both cooled and uncooled, and heat shields. In the Phase I proposal, offerors should demonstrate a clear understanding and familiarity with the technical issues and should clearly explain the uniqueness of their approach. Phase I will establish the technical feasibility of candidate, innovative weaving methods along with matrix consolidation. Limited, small specimen mechanical testing should be performed to aid in assessing feasibility. Phase II will scale up the process to larger structural sections, generate mechanical property data, and perform testing to verify structural integrity over required lifetimes. Potential Phase III customers include the automotive industry and military and civilian aerospace.

AF93-186TITLE: Structural Integrity Analysis Techniques for Extreme EnvironmentsAF93-186TITLE: Structural

Integrity Analysis Techniques for Extreme Environments

CATEGORY: Basic Research

OBJECTIVE: Methods to measure crack length and estimate the life of structural components in extreme environments.

DESCRIPTION: Future high performance aerospace vehicles such as the National Aero-Space Plane (NASP), will operate in extreme thermomechanical environments. The operating temperature of their structural components can easily exceed 2000°F. Properties of materials and joints are greatly affected by these temperatures. Therefore, to ensure the safety of these vehicles, reliable methods to measure crack growth and estimate life remaining for small structural component test specimens are required. Since future vehicle components will consist of metallic, polymer-matrix composite, metal-matrix composite, and refractory-matrix composite materials, it is desirable that these methods be applicable to a number of material systems. Phase I should result in the development of innovative methods to measure crack growth accurately and estimate life for small structural component test specimens operating at high temperatures. Phase II includes validation over a broader data base and would yield a prototype product. Phase III of this project would entail the refinement and commercial offering of these techniques

AF93-187TITLE: Enhanced Thermal Conductance in Nonmetallic Heat ExchangersAF93-187TITLE: Enhanced Thermal Conductance in Nonmetallic Heat Exchangers

CATEGORY: Basic Research

OBJECTIVE: Enhanced thru-thickness thermal conductance of refractory composite heat exchangers operating at 2500°F to 2800°F.

DESCRIPTION: Airbreathing propulsion systems of future high- performance aerospace vehicles such as NASP and NASP derivatives, will operate at heat fluxes substantially greater than current state-of-the-art airbreathing engines.

In order to reliably withstand these high heat fluxes, regeneratively cooled channeled structures fabricated from copper alloys, high-temp iron and cobalt-based superalloys and refractory composites such as coated C/C and C/SiC are receiving developmental consideration. These materials must be able to contain high-temperature, high-pressure hydrogen without severe leaking or excessive degradation of mechanical properties while surviving highly oxidized and reducing combustion products. C/C and C/SiC refractory composites have demonstrated high-temperature strengths superior to superalloys by 700 to 1200° F and coatings have been developed exhibiting reasonably acceptable oxidation resistance to 3000° F. In order to use this capability in a heat exchanger, methods to increase the thermal conductivity through the heat exchanger walls are needed while containing the hot high-pressure hydrogen and avoiding unacceptable permeation. Current designs involve nonpermeable refractory metal channel liners in the carbon or ceramic matrix composites. Achieving adequate interfacial heat transfer is a leading problem with this design approach and alternate approaches incorporating alternate fiber architectures and nonmetallic channel wall liner materials are needed. The Phase I program will establish a candidate method. During Phase II, the contractor will build and demonstrate a prototype heat exchanger and in Phase III, the contractor will refine and market his process and/or material.

AF93-188TITLE: Surface Measurement of Hypersonic Boundary Layer Instability ModesAF93-188TITLE: Surface Measurement of Hypersonic Boundary Layer Instability Modes

CATEGORY: Basic Research

OBJECTIVE: Surface-mounted sensor capable of measuring stationary or traveling instability waves in hypersonic

boundary layers.

DESCRIPTION: Measurements of the growth and spatio-temporal frequency content of instability waves in hypersonic boundary layers are required to diagnose transition prediction techniques, to diagnose the dominant instabilities leading to transition in wind tunnel and flight experiments, and as a precursor to any active control scheme. Surface mounted sensors are highly desirable for these measurements, since they are relatively nonintrusive and easily mounted. Such surface mounted sensors as hot films and microphones have been used successfully for these measurements in subsonic flow, but no such measurement capability has been demonstrated for hypersonic flow. A number of sensors, including optical, hot film, pitot pressure, surface microphones, etc, exists for detecting transition locations in hypersonic flow. While these instruments give some indication of where a hypersonic boundary layer transitions from laminar to turbulent, they return little, if any, information about the instability growth leading to transition. There are two primary reasons for this. First, instability waves in hypersonic flow possess maximum energy at the edge of the boundary layer and, in contrast to subsonic flow, there is little coupling between the waves and the wall variables. Mass flux variations caused by hypersonic instability waves can be several percent at the boundary layer edge, but their surface footprint may be extremely small in magnitude. Second, the frequency range of traveling instability waves in hypersonic flow stretches or exceeds the frequency response of existing instrumentation. The detection of stationary (cross flow or Goertler) instability waves is also problematic, since it is necessary to look for small variations in the spatial distribution of the mean measurement quantity. The measurement of hypersonic instability waves is the most demanding test of such instrumentation. If the instrumentation has enough sensitivity for this task, it should in principle be usable at lower Mach numbers and in turbulent flow. The Phase I effort will analyze the proposed measuring system and demonstrate its feasibility. In Phase II, the system will be installed and demonstrated at Wright Laboratory. In Phase III, the technology demonstrated in the first two phases will be commercially exploited.